

ESMC-TR-88-01

A GUIDE FOR RECERTIFICATION OF
GROUND BASED PRESSURE VESSELS
AND LIQUID HOLDING TANKS



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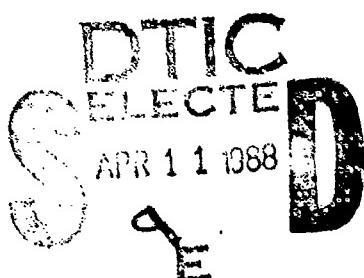
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 This guideline supports the USAF recertification requirements contained in the "Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems," MIL-STD-1522. In addition, this guideline has wide applicability to vessels containing high pressure gases, cryogenics, hypergolics, or other hazardous fluids. The overall objective of this guideline is to present a step-by-step methodology designed to evaluate the current condition of vessels which have been in operation for a number of years in a wide variety of service environments. The methodology presented addresses four major areas which may be the root cause of service-related failures: (1) corrosion, (2) stress and fatigue, (3) design, fabrication, and installation, and (4) operation and maintenance. The methodology for recertification of vessels and tanks is divided into five phases: (1) documentation retrieval and review, (2) engineering assessment, (3) inspection and test planning, (4) inspection and test implementation, and (5) safe-life evaluation and inservice inspection plan initiation. Each of the phases contains a decision

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logic and a total of 53 specific activities involved in the recertification process. Each activity includes a purpose, description, specific steps, major obstacles, major decisions, input, output, and sample references. The methodology is designed to be flexible, thus, allowing its use on both well-documented and maintained vessels, as well as those vessels lacking design documentation or operating history.

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COMMENT FORM

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1. USAF solicits your comments concerning this guideline so that its usefulness may be improved in later editions. Send any comments to the following address:

Directorate of Safety
Attn: B.L. Webb
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Patrick Air Force Base, Florida 32925

2. Comments are solicited in the following areas:

- a. Is the guideline adequate to support development of a recertification program?
- b. What improvements would make the guideline more adequate?
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**A GUIDE FOR RECERTIFICATION OF GROUND
BASED PRESSURE VESSELS AND LIQUID HOLDING TANKS**

CONTENTS	PAGE
Report Documentation Page	i
Comment Form	iii
Acknowledgments	iv
Table of Contents	v
List of Figures	ix

**1.0 INTRODUCTION TO THE CERTIFICATION/RECERTIFICATION
PROGRAM**

1.1 Background.....	1
1.2 Overview of the Program.....	3

2.0 DEFINITIONS

2.1 Certification	10
2.2 Derated Vessel.....	10
2.3 Design Pressure.....	10
2.4 Fail-Safe.....	10
2.5 Hydrostatic Test	10
2.6 Inservice Inspection	10
2.7 Liquid Holding Tank	11
2.8 Maximum Allowable Working Pressure (MAWP).....	11
2.9 Major Inspections	11
2.10 Major Inspection Interval.....	11
2.11 Maximum Operating Pressure (MOP)	11
2.12 Pneumatic Test	11
2.13 Pressure Vessel	12
2.14 Recertification	12
2.15 Recertification Period	12
2.16 Routine Inspections.....	12
2.17 Routine Inspections Intervals	12

CONTENTS	PAGE
2.18 Safe-Life	12
3.0 FORMAT OF PHASES AND ACTIVITIES.....	13
4.0 PROGRAM ACTIVITIES.....	22
4.1 Phase I: Documentation Retrieval and Review	23
101 Perform Survey of Vessel.....	23
102 Retrieve and Review Operations Documentation.....	24
103 Retrieve and Review Maintenance Documentation	25
104 Retrieve and Review Engineering Documentation..... (Coded Vessels)	26
105 Retrieve and Review Engineering Documentation..... (Non-Coded Vessels)	27
106 Establish Configuration Baseline File for Vessel	28
4.2 Phase II: Engineering Assessment	31
201 Assess Vessel Configuration and Operation Using Agency Requirements	31
202 Calculate Vessel MAWP Using ASME Boiler and Pressure Vessel Code Section VIII, Division 1	32
203 Assess Vessel MAWP Using ASME Boiler and Pressure Vessel Code Section VIII, Division 2	33
204 Derate Vessel to Calculated MAWP.....	34
205 Evaluate Overpressurization Protection Using..... ASME and Agency Requirements	35
206 Adjust Relief Valves to Acceptable Setting	36
207 Review and Assess Fabrication (Materials and Welding) vs. Lessons Learned	37
208 Evaluate Susceptibility of Metal to Corrosion	38
209 Review History of Cyclic Operation or Extraordinary	39
Transients	

	CONTENTS	PAGE
210	List Discrepancies and Concerns from Reviews, Evaluations or Assessments	40
211	Retain Concerns in Files for Reference	41
212	Establish List of Discrepancies by Priority..... (Immediate, Short-term, Long-term)	42
213	Address Concerns with Immediate Priority.....	43
214	Remove from Service and Establish "Return to Service" Plan (as applicable)	44
215	Address Concerns with Short- and Long-term Priority	45
216	Establish Engineering and/or Inspection/Test	46
	Objectives	
217	Perform Additional Engineering Analysis (as applicable)	47
4.3	Phase III: Inspection/Test Plan.....	51
301	Define Inspection and Testing Requirements to Resolve Concerns	51
302	Conduct Field Inspection Verification	52
303	Develop Inspection and Test Procedures and Acceptance	53
	Criteria	
304	Develop Work Packages	54
4.4	Phase IV: Inspection/Test Implementation.....	55
401	Perform Inspections and Tests	55
402	Characterize and Analyze Discontinuities	56
403	Perform Engineering Analysis to Determine Disposition	57
404	Perform Follow-up Engineering and Specify Additional	58
	Inspections and Tests	
405	Remove from Service and Finalize Disposition	59
4.5	Phase V: Final Evaluation and ISI Initiation.....	63

	CONTENTS	PAGE
501	Determine the Number of Stress Cycles Per Year Experienced by and Expected for the Vessel	63
502	Perform Detailed Safe-Life Analysis	64
503	Perform Simplified Safe-Life Analysis	65
504	Develop Destructive Test Plan to Provide Detailed Input for Fatigue Analysis or Fracture Mechanics Analysis	66
505	Perform Detailed Fatigue Analysis or Fracture Mechanics Analysis and Safe-Life Analysis	67
506	Perform Engineering Analysis to Determine Disposition	68
507	Remove From Service and Finalize Disposition	69
508	Derate to MOP +10% and Adjust Relief Devices	70
509	Calculate Remaining Safe-Life Based on Corrosion Rate	71
510	Perform Engineering Analysis to Estimate Corrosion Damage and Remaining Safe-Life	72
511	Calculate Remaining Safe-Life Based Creep Rate	73
512	Perform Engineering Analysis to Creep Damage and Remaining Safe-Life	74
513	Calculate Safe-Life Based on Additional Failure..... Mode	75
514	Compare Safe-Life as Predicted by Failure Mechanisms	76
515	Choose Most Limiting Safe-Life.....	77
516	Define Recertification Period Equal to 20 years	78
517	Define Recertification Period Equal to Remaining Safe-Life	79
518	Develop Inservice Inspection Plan Based on Recertification Period	80
519	Resolve All Outstanding Concerns and Establish MAWP and Service Restrictions	81
520	Establish Overpressurization Protection Requirements	82
521	Establish Date for Next Recertification and Initiate ISI	83

LIST OF FIGURES

	Page
1. Major Root Causes of Service Related Failures in Pressure Vessels	2
2. Overview of Recertification Program Model	4
3. Sample Vessel Lifetime and Program Application	9
4. Summary of Major Goals for Recertification Process	14
5. Recertification Program Flowchart	15
6. List of Program Phases and Activities	17
7. Phase I: Documentation Retrieval and Review	29
8. Phase II: Engineering Assessment	49
9. Phases III and IV: Inspection/Test Planning and Implementation	61
10. Phase V: Final Evaluation and ISI Initiation	85

1.0 INTRODUCTION TO THE RECERTIFICATION PROGRAM

1.1 Background

The certification or recertification of pressure vessels and liquid holding tanks involves numerous interrelated activities and multiple decisions. These activities and decisions are based on government regulations, standards, or manuals, coupled with engineering practices presented in national consensus standards. Programs of this type for large mechanical systems have only recently been initiated at government and industrial facilities. Recent major failures and the overall aging of large, high pressure and/or high hazard systems has accelerated the interest and concern of both facility operators and the general public. The program which follows addresses the major concerns raised over the past several years and outlines the overall recertification process for above-ground vessels and tanks by:

- Defining and describing all significant activities required by this program,
- Presenting a methodology to be used, with appropriate decision logic, which illustrates the interrelationship of all activities, and
- Instructing the user on important steps and obstacles found in each of the activities.

This program addresses four major areas which may be the root cause of service related failures: (1) corrosion; (2) stress and fatigue; (3) design, fabrication, and installation; and (4) operation and maintenance (O&M). Each of these areas can be further broken down into specific failure mechanisms which may be present at a specific point in the vessels lifetime or may be progressive throughout its lifetime. Figure 1 presents a list of the most significant failure mechanisms associated with the operation of pressure vessels and pressurized systems. The recertification evaluation of each vessel should consider all appropriate failure mechanisms, and address those of concern to future O&M activities. Each of the failure mechanisms addressed should be analyzed for root cause (e.g. environment, vibrational operation mode, etc.). Controls or an ongoing monitoring program should be implemented (e.g. corrosion protection, isolation of vibration source from vessel, etc.) to alleviate, arrest, or track areas of concern. A failure does not necessarily have to be catastrophic. It can result from a wide variety of conditions which, over time, degrade overall performance, especially during critical evolutions. The major failure theories, such as maximum stress and shear theories, have historically been used to predict and prevent catastrophic failure. These theories do not

**FIGURE 1. MAJOR ROOT CAUSES OF SERVICE
RELATED FAILURES IN PRESSURE VESSELS**

CORROSION

- General Corrosion
- Galvanic Corrosion
- Local Corrosion (Pitting)
- Intergranular Corrosion
- Crevice Corrosion
- Stress-Corrosion Cracking and Corrosion Fatigue
- Stress-Enhanced Corrosion
- Erosion
- Corrosion by Soil or Insulation

STRESS & FATIGUE

- Overpressure
- External Loading
- Pressure Cycling
- Variations in Flow
- Vibration
- Thermal Cycling
- Dissimilar Metal Welds
- High Temperature Creep
- Mechanical Shock

DESIGN, FABRICATION, AND INSTALLATION

- Design Deficiencies (design notches, weld-joint design, reinforcements)
- Material Deficiencies
 - Mechanical Notches (laminations, laps, seams, cracks)
 - Metallurgical Notches (hot shortness, hardness variations, notch brittleness)
- Welding Deficiencies (cracks, incomplete fusion, lack of penetration, overlap, undercut, arc strikes, porosity, slag inclusions, weld spatter, residual stresses, distortion)
- Installation Deficiencies (fitup, alignment, attachments, supports)

OPERATION AND MAINTENANCE (O&M) DEFICIENCIES

- Refurbishment Damage
- Modification and/or Repair Deficiencies
- Operation beyond allowable limits
- Maintenance Deficiencies

account for failures introduced by such mechanisms as creep, pitting, or erosion. Therefore, the prediction and prevention of failures requires not only load and strength analysis, but more importantly, a practical understanding of material characteristics in an operating environment. This includes familiarity with the long-term effects of corrosion, stress, fatigue and temperature. If a failure mode cannot be prevented by implementing a proven control, then a safe-life prediction is necessary for that failure mode. Safe-life prediction can be performed analytically or experimentally.

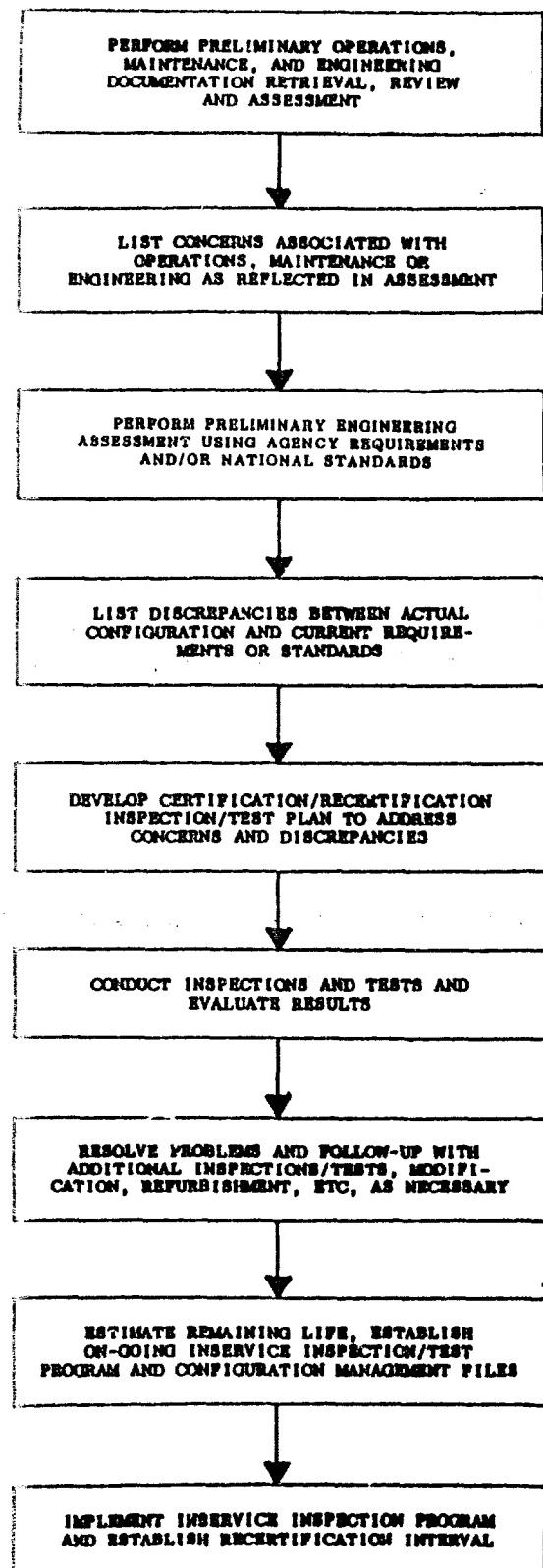
1.2 Overview of the Program

Figure 2 illustrates the major aspects of the recertification program. This program is intended to provide guidance on the steps necessary to address the wide variety of failure mechanisms, and associated engineering decisions, which can occur at an operating facility. This program does not replace good engineering judgement which is necessary to assess and evaluate each of the concerns and discrepancies encountered in the recertification process. The program was developed based on a number of conservative assumptions and is, therefore, applicable to both well documented and maintained vessels as well as those with limited documentation or history of maintenance. These conservative assumptions include the following four major items, however, the methodology may be applied in all cases.

- The vessel has been in service for a number of years with minimal O&M history and incomplete engineering documentation.
- The vessel was designed and fabricated to government specifications or national standards, however traceability may be unavailable.
- Documented and undocumented modifications may have been made to the vessel during its lifetime, as well as extraordinary pressure or temperature transients.
- The industry's knowledge base associated with materials, welding, analysis, etc., may have expanded to address practices which were considered satisfactory at time of manufacture, but are concerns today.

In general, the program was developed to require indepth engineering and inspection/testing for a variety of concerns that may be encountered. Each vessel

**FIGURE 2. OVERVIEW OF RECERTIFICATION
PROGRAM MODEL**



recertified is taken on a case-by-case basis. When, for example, (1) extensive documentation is available, (2) no concerns are encountered, and (3) failure mechanisms result in minimal hazard or are fail-safe, then the level of inspection/test or follow-up action is significantly reduced.

As described earlier, one of the objectives of this program is to establish guidelines on the evaluation and monitoring of vessels which are currently in service. The evaluation should determine the safe-life remaining for the vessel based on analytical (including stress, fatigue, and fracture mechanics analysis), or empirical methods (corrosion, creep and erosion assessment). This assessment should establish the safe-life based on the most rapidly developing failure mode. That is, if corrosion or creep will limit the life of the vessel, then it should be used to establish safe-life, rather than fatigue. The safe-life remaining is used as a basis for determination of recertification intervals and major and routine inservice inspection and test requirements. This model assumes that the engineer performing recertification analysis will apply an appropriate safety factor to develop the relationship between the recertification period and the remaining safe-life. This may be applied directly in the evaluation of safe-life, or may be applied as a reduction factor to the safe-life when computing the recertification period and associated major and routine inspection intervals. The following examples are designed to illustrate the application of safety factors to the calculation of safe-life and recertification period.

- **Fatigue:** The design fatigue curves in the ASME Boiler & Pressure Vessel Code are based on applying a reduction factor (safety factor) of two on total strain range and 20 on the mean number of cycles to failure. This philosophy may also be used if design curves are developed as part of a test program using actual material samples. Due to the fact that the recertification program is structured to estimate the number of cycles to failure, and due to the fact that there is a large conservatism in calculation of the number of cycles, no additional safety factor need be applied in calculating the recertification period. That is, the recertification period, as established from the Code fatigue analysis, would equal the estimated cyclic life. This relationship between life and recertification period assumes that major and routine inspections are performed throughout life. If inspections cannot be performed to satisfactorily assess the integrity of the vessel, then an additional safety factor is recommended. This safety factor is generally taken to be 4:1, therefore establishing the recertification period at one quarter of the estimated safe-life, as calculated from the fatigue analysis.

- Creep: The establishment of a safety factor, when creep is of significant concern, is directly related to the confidence that the engineer has in the material composition and properties. Since substitute material is sometimes used in fabrication, the potential for service-induced damage may be increased. If there is high confidence in the materials composition and available stress-rupture data (for example in an ASTM publication), then a Larson-Miller parametric (LMP) approach can be used for analysis, and determination of the recertification period. A 2:1 ratio between recertification period and creep life may be used if reasonable confidence exists in the materials stress-rupture characteristics. If there is little confidence in material composition and properties, then material samples should be taken and an appropriate adjustment in safety factor should be made. As with the fatigue failure mechanism, the relationship between safe-life and recertification period assumes that major and routine inspections are performed throughout life. If inspections cannot be performed to satisfactorily assess the integrity of the vessel, then an additional safety factor is recommended.
- Corrosion: General corrosion or erosion resulting in a uniform reduction in wall thickness can result in wall thicknesses approaching, or becoming less than, the minimum wall thickness as required by the ASME Boiler & Pressure Vessel Code. The corrosion or erosion rate, therefore, may be used to define the corrosion or erosion lifetime, assuming uniform reduction in wall thickness. As described in previous failure modes, if the corrosion/erosion rate can be defined from nondestructive examination (ultrasonic wall thickness measurements), and if routine inspections are performed to monitor the reduction in wall thickness, then no additional safety factor need be placed on the relationship between corrosion/erosion safe-life and the recertification period. If the corrosion is related to a non-uniform attack in the material (stress-corrosion cracking, pitting, etc.), then additional analysis, examination, and safety-factors should be applied to address concerns.

More information on these topics and service-related failures may be found in the current edition of Mark's Standard Handbook for Mechanical Engineers, published by McGraw-Hill Book Company, and Defects and Failures in Pressure Vessels and Piping, by Helmut Thielisch, published by the Robert E. Krieger Publishing Company in 1975. There

are numerous other sources of information on this subject, a sampling of these references is contained on the individual activity pages which follow.

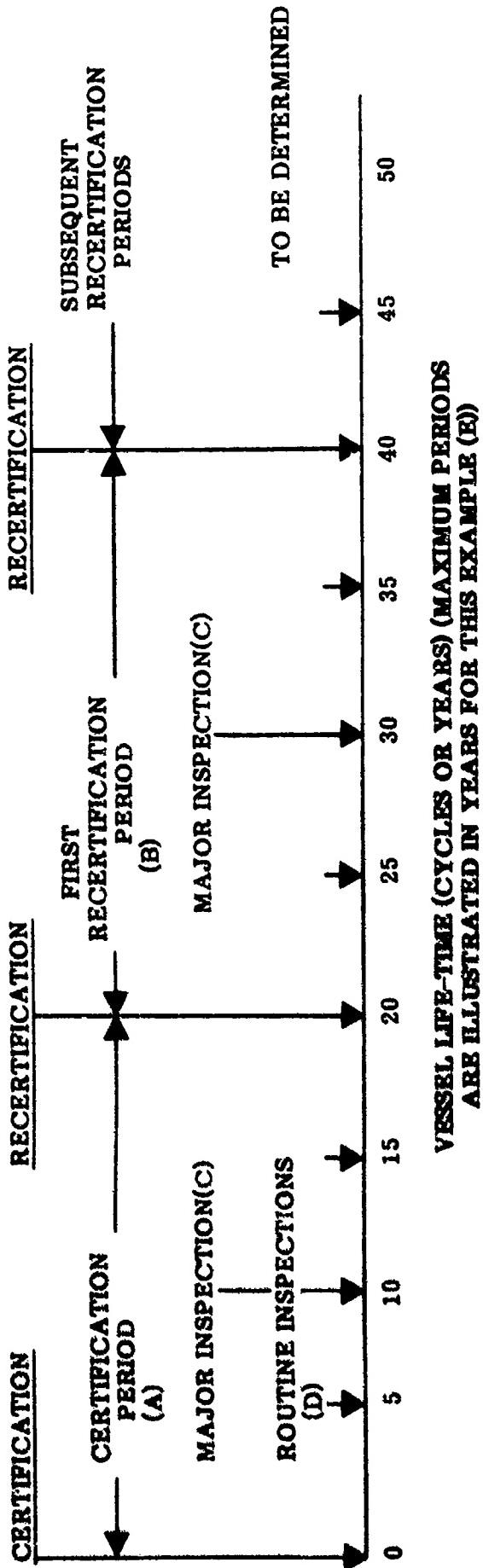
Information provided in this program should be used as generic guidance in developing vessel-specific recertification policies and plans. A sample application of the program is contained in Figure 3. In the past, the long-term integrity of a welded pressure vessel or piping system was tested only by a proof-pressure hydrostat when changes in service requirements were made; for example, a vessel was relocated or a system was reconfigured. There are several deficiencies in the test method, if used alone. Although it provides confidence in both base and weld metals, it cannot detect flaws such as internal cracks, excessive porosity, lack of fusion, and lack of penetration, which tend to cause failure with age and usage. These flaws can be detected by nondestructive examination techniques and analyzed to determine impact on future operations. Therefore, the monitoring of weld integrity with inservice inspection techniques, in conjunction with periodic proof-testing, provides the highest degree of confidence in safe system operation.

As illustrated in Figure 1, there are a wide variety of root causes which may cause a vessel failure. It is difficult to assure that each is addressed in sufficient detail to completely negate the possibility of failure. Therefore, this program is designed to outline a methodology which concentrates effort on those root causes which have historically had the greatest probability of causing failure. These include corrosion/erosion, fatigue, creep (for high temperature applications), along with design, fabrication, modification, or repair deficiencies introduced at initial fabrication or through routine operation and maintenance. Each of these areas can be approached on a methodical basis using good engineering judgement. For example, traditional fatigue design analysis approaches using ASME Boiler and Pressure Vessel Code, Section VIII, Division 2, can be used to characterize applied cyclic loading with an alternating pressure or temperature stress. The maximum stress can be used to enter fatigue design curves (alternating stress versus cycles) to establish the number of permissible design cycles, N . The fraction of vessel life expended can be assessed by dividing the number of historical service cycles, n , by the design cycles, N . The fraction of remaining life is then $1-(n/N)$. Alternatively, fatigue damage can be assessed using a linear elastic fracture mechanics (LEFM) approach. In this approach, fatigue damage is assessed through crack growth calculations. By calculating crack growth and critical crack sizes,

one can determine the number of stress cycles a component can withstand before failure occurs. Given sufficient data, a high confidence estimate of end of life is possible. Of these two approaches, the traditional fatigue approach is most widely used, however, for ground support equipment, LEFM is generally used when cracks have been found, or assumed, and specific analysis is required to estimate the number of cycles to failure. Both of these approaches are recommended as appropriate to the specific recertification application.

The primary reason for development of the safe-life estimate, beyond determination that the vessel has not exceeded safe-life, is to develop recertification periods along with inservice inspection intervals. Based on industry experience, a maximum recertification period of 20 years is recommended. Major and routine inservice inspections are then prescribed throughout the recertification period to provide assurance that concerns developed during prior recertification periods are monitored and re-evaluated as necessary. Since the safe-life analysis provides the number of cycles or time (as related to an estimated number of cycles per year) to the possibility of a failure, most low cycle vessels, at ambient temperature, in noncorrosive environments, will have a safe-life calculated well above the 20 year maximum set by this program. This is not to imply a reduction of safety at the 20 year point, but is intended to provide adequate review and re-evaluation of vessels on a period which reflects advances in knowledge of design, fabrication, material, and inspection and test requirements. Vessels in high cycle, high temperature (typically greater than 700 degrees F for carbon steel), or highly corrosive environments are likely to have safe-life calculated below the 20 year maximum and are, thus, more closely monitored due to the higher probability that one of the listed root cause failure mechanisms may result in failure.

**FIGURE 3. SAMPLE VESSEL LIFETIME
AND PROGRAM APPLICATION**



- Vessel is initially certified for a 20 year period, the maximum period allowed by this program.
- Following Certification at the 20 year point, it is recertified for life-extension for an additional 20 year period (maximum). This process is continued until analysis, inspections, and/or tests indicate the vessel is no longer safe for continued operation.
- Major inspections (as applicable) are established from 1/4 to 1/2 of the recertification interval and typically include volumetric examination.
- Routine inspections are established from 1/10 to 1/2 of the major inspection interval and typically include visual and ultrasonic thickness examinations.
- The intervals illustrated in this example are the maximum inspection and recertification intervals recommended in this guideline. Therefore, depending on service and environmental conditions, age, and additional concerns, the intervals may be determined to be shorter. Inspections and recertification would be required more often.

2.0 DEFINITIONS

2.1 Certification

Documentation qualifying a vessel to operate in its particular service environment within specific operational parameters, including maximum allowable working pressure and temperature limitations.

2.2 Derated Vessel

A pressure vessel qualified to operate at a lesser maximum allowable working pressure (MAWP) and/or temperature limit, as defined from recertification analysis and/or testing.

2.3 Design Pressure

The pressure used in the design of a vessel for the purpose of determining the minimum permissible thickness or physical characteristics of the different parts of the vessel. (When applicable, static head shall be added to the design pressure to determine the thickness of any specific part of the vessel).

2.4 Fail-Safe

The ability to sustain a failure without causing loss of vehicle systems or loss of personnel capability.

2.5 Hydrostatic Test

The test of a pressure vessel during which the vessel is filled with a liquid and pressurized to a designated level in a manner prescribed in the applicable code or standard.

2.6 Inservice Inspection

Visual and/or nondestructive examination of a vessel during its service life.

2.7 Liquid Holding Tank

A low pressure or atmospheric storage tank containing materials which could produce a personnel, equipment or environmental hazard if released, including hypergolics, hydrocarbon fuels, and other related substances.

2.8 Maximum Allowable Working Pressure (MAWP)

The maximum gage pressure permissible at the top of a completed vessel in its operating position at its design temperature. This pressure is based on calculations for every element of the vessel using nominal thicknesses exclusive of allowances for corrosion and thickness required for loadings other than pressure. It is the basis for pressure setting of the pressure relieving devices protecting the vessel.

2.9 Major Inspections

A nondestructive examination which assesses the volumetric integrity of the vessel. This may include radiography, ultrasonic, or acoustic emissions examination. Proof testing may be used as an alternative.

2.10 Major Inspection Interval

Typically prescribed at intervals of one quarter to one half of the recertification period, depending on service conditions and failure modes. Major inspection intervals are prescribed as part of recertification analysis.

2.11 Maximum Operating Pressure (MOP)

The maximum pressure at the top of a pressure vessel at which it normally operates. It shall not exceed the maximum allowable working pressure and it is usually kept at a suitable level below the setting of the pressure relieving devices to prevent their frequent opening.

2.12 Pneumatic Test

A test of a pressure vessel in which a gas is introduced and pressurized to a designated level in a manner prescribed in an applicable code or standard.

2.13 Pressure Vessel

Any container used for the containment of pressure, either internal or external.

2.14 Recertification

The procedure (appropriate analysis, inspections, tests and documentation) which qualifies a previously certified vessel to continue or be returned to operations at a designated pressure. Recertification should include a requirement for periodic proof pressure testing.

2.15 Recertification Period

The interval of time a vessel is permitted to operate between scheduled recertifications. The maximum Recertification Period is established at 20 years, not to exceed the safe-life, for this program.

2.16 Routine Inspections

Visual and nondestructive examinations which assess the overall condition of the vessel. This may include visual external examinations and ultrasonic wall thickness measurements to detect corrosion, erosion, deformations, or other general features indicating possible loss of integrity. Follow-up inspections may be required.

2.17 Routine Inspection Intervals

Typically prescribed at intervals of one tenth to one half of the major inspection interval, depending on service conditions. Routine inspection intervals are prescribed as part of recertification analysis.

2.18 Safe-Life

The period during which a vessel is predicted not to fail in the expected operating environment.

3.0 FORMAT OF PHASES AND ACTIVITIES

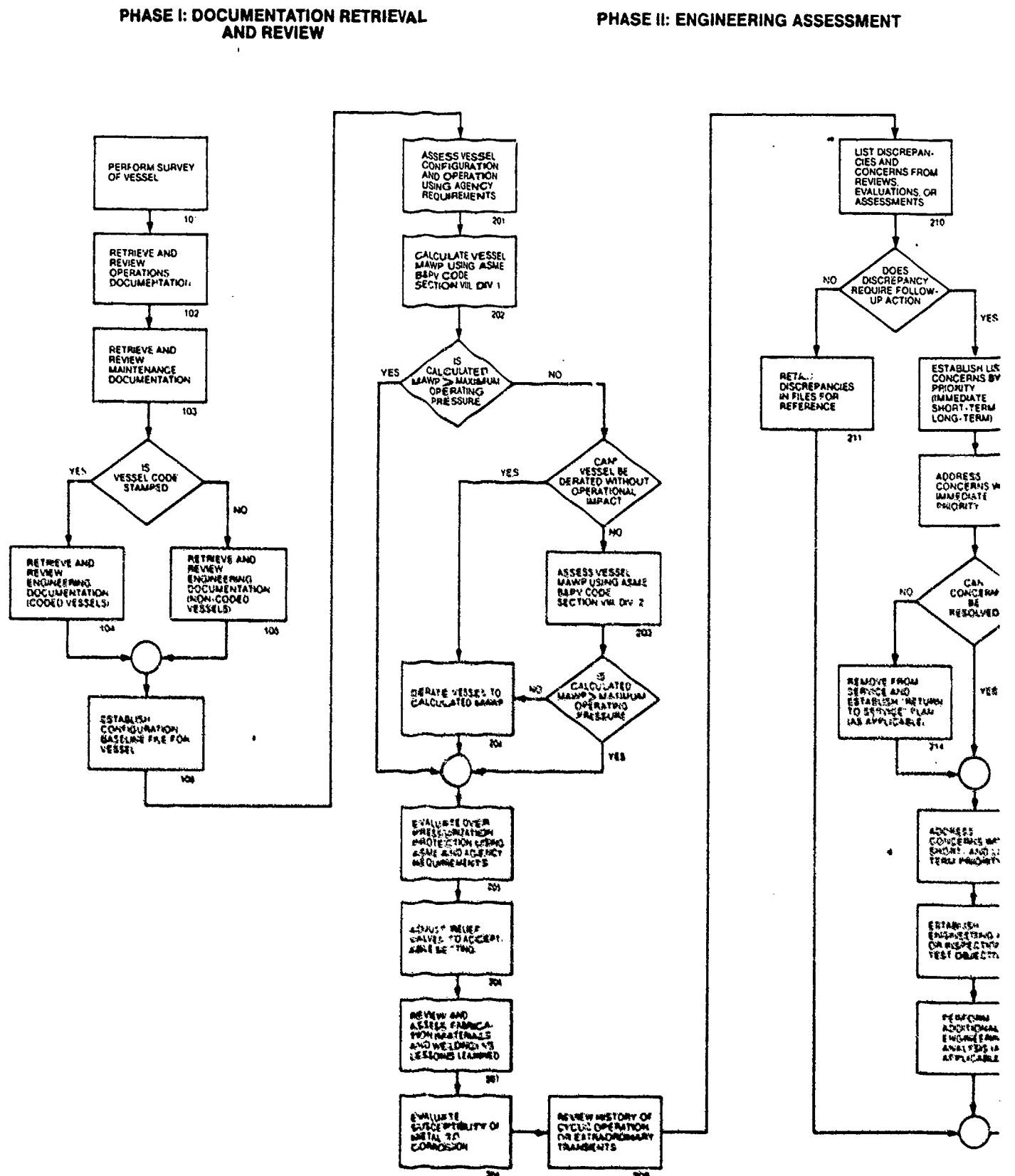
The recertification process is divided into five phases, each of which addresses a major goal for the program. Figure 4 summarizes each of the phases and its associated major goal. The five phases are further divided into activities, each of which addresses a unique aspect of the process. The activities are the primary building blocks of the program, and as such are interrelated to the major decision-making logic, as presented in Figure 5. Figure 5 presents all five phases and all activities showing the interrelationships of the decision making process. In turn, each activity will involve separate steps and additional decisions to implement the entire program.

Each activity is presented on a separate numbered sheet, with each sheet containing detailing information on the necessary steps to complete the activity. The first digit in the identification number corresponds to the number of the phase, with the second two digits designating a unique activity number. Following each group of activities associated with a particular phase is a phased flowchart illustrating the interrelationships of the activities and decision points. A complete list of all phases and activities is contained in Figure 6.

**FIGURE 4. SUMMARY OF MAJOR GOALS FOR
RECERTIFICATION PROCESS**

<u>PHASE</u>	<u>TITLE</u>	<u>GOAL/OBJECTIVE</u>
I	Documentation Retrieval, and Review	Develop list of preliminary concerns requiring detailed review and assessment
II	Engineering Assessment	Action plan for follow-up activities to resolve concerns
III	Inspection/Test Plan	Develop work packages for inspection/testing
IV	Inspection/Test Implementation	Designate final action or dis- position for vessel from inspec- tion/test results
V	Final Evaluation and ISI Initiation	Establishment of ISI program

FIGURE 5. RECERTIFICATION PROGRAM



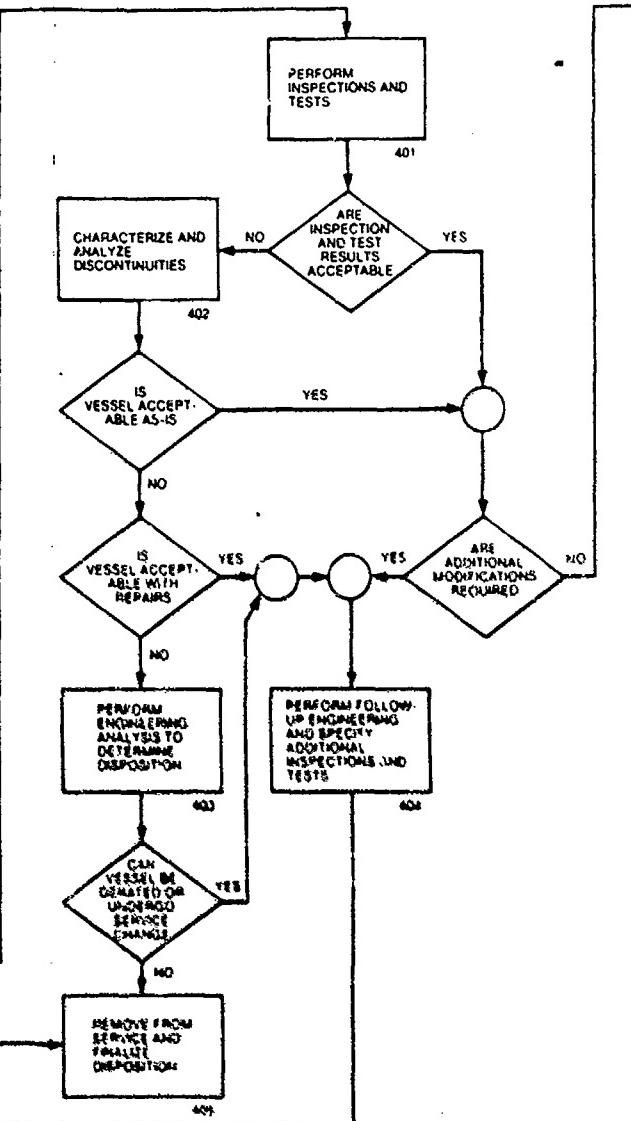
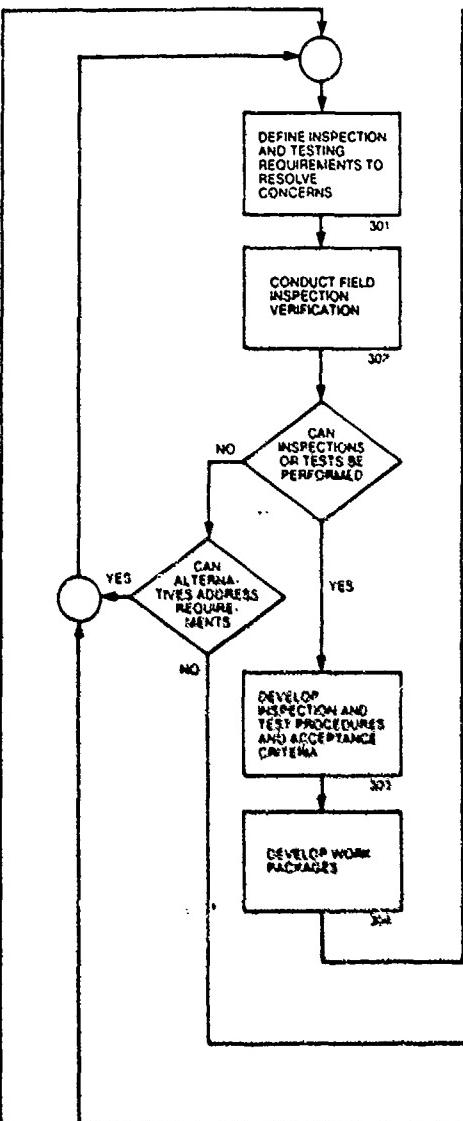
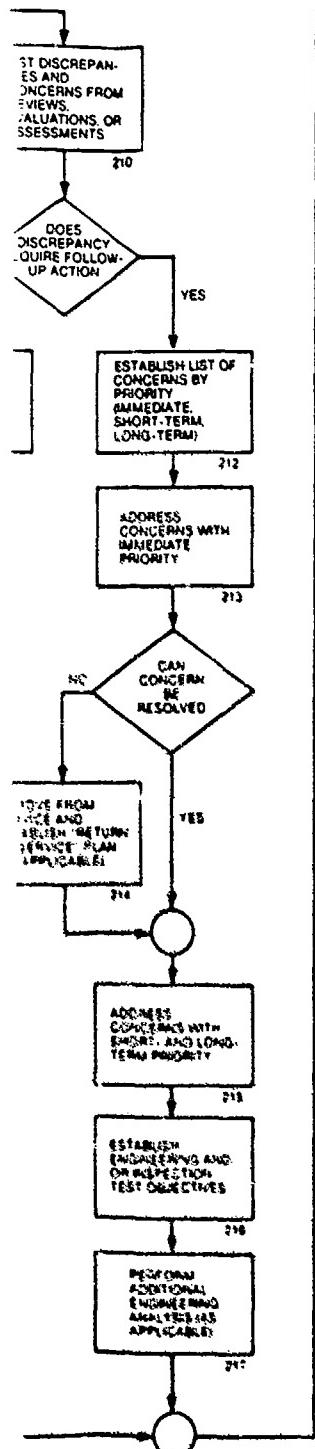
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MONITORING AND INSPECTION PROGRAM FLOWCHART (Sheet 1 of 2)

MENT

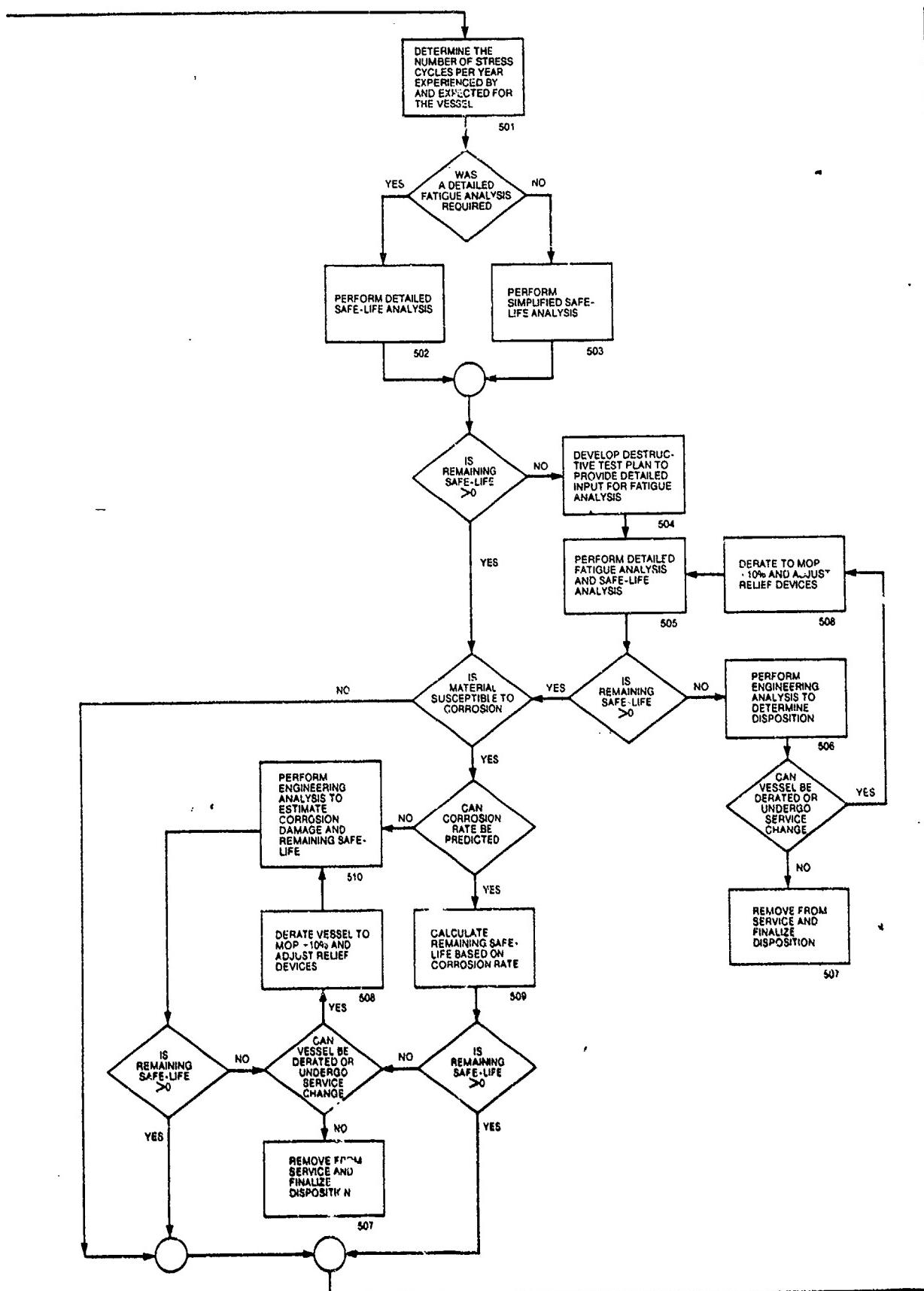
PHASE III: INSPECTION/TEST PLANNING

PHASE IV: INSPECTION/TEST IMPLEMENTATION

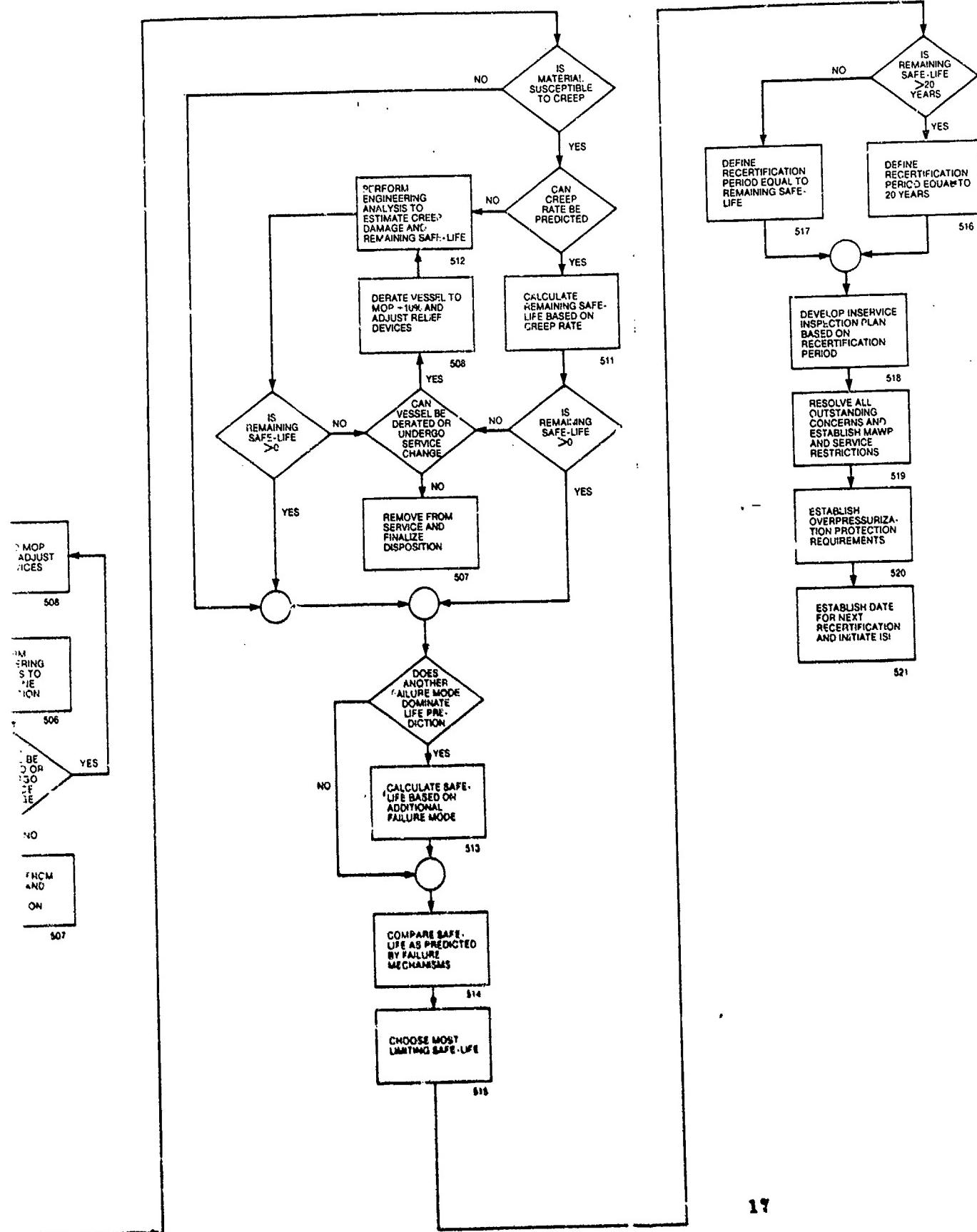


B

FIGURE 5. RECERTIFICATION PROGRAM F.



IFICATION PROGRAM FLOWCHART (Sheet 2 of 2)



**FIGURE 6. LIST OF
PROGRAM PHASES AND ACTIVITIES**

I. Documentation Retrieval and Review

- 101 Perform Survey of Vessel
- 102 Retrieve and Review Operations Documentation
- 103 Retrieve and Review Maintenance Documentation
- 104 Retrieve and Review Engineering Documentation (Coded Vessels)
- 105 Retrieve and Review Engineering Documentation (Non-Coded Vessels)
- 106 Establish Configuration Baseline File for Vessel

II. Engineering Assessment

- 201 Assess Vessel Configuration and Operation using Agency Requirements
- 202 Calculate Vessel MAWP Using ASME Boiler and Pressure Vessel Code Section VIII, Division 1.
- 203 Assess Vessel MAWP Using ASME Boiler and Pressure Vessel Code Section VIII, Division 2
- 204 Derate Vessel to Calculated MAWP
- 205 Evaluate Overpressurization Protection Using ASME and Agency Requirements
- 206 Adjust Relief Valves to Acceptable Setting
- 207 Review and Assess Fabrication (Materials and Welding) vs. Lessons Learned
- 208 Evaluate Susceptability of Metal to Corrosion
- 209 Review History of Cyclic Operation or Extraordinary Transients
- 210 List Discrepancies and Concerns from Reviews, Evaluations and Assessments
- 211 Retain Concerns in File for Reference
- 212 Establish List of Discrepancies by Priority (immediate, short-term, long-term)
- 213 Address Concerns with Immediate Priority
- 214 Remove from Service and Establish "Return to Service" Plan (as applicable)
- 215 Address Concerns with Short - and Long-Term Priority
- 216 Establish Engineering and/or Inspection/Test Objectives
- 217 Perform Additional Engineering Analysis (as applicable)

III. Inspection/Testing Plan

- 301 Define Inspection and Testing Requirements to Resolve Concerns
- 302 Conduct Field Inspection Verification
- 303 Develop Inspection and Test Procedures and Acceptance Criteria
- 304 Develop Work Packages

IV. Inspection/Test Implementation

- 401 Perform Inspections and Tests
- 402 Characterize and Analyze Discontinuities
- 403 Perform Engineering Analysis to Determine Disposition
- 404 Perform Follow-up Engineering and Specify Additional Inspections and Tests
- 405 Remove from Service and Finalize Disposition

V. Final Evaluation and ISI Initiation

- 501 Determine the Number of Stress Cycles Per Year Experienced by and Expected for the Vessel
- 502 Perform Detailed Safe-Life Analysis
- 503 Perform Simplified Safe-Life Analysis
- 504 Develop Destructive Test Plan to Provide Detailed Input for Fatigue Analysis
- 505 Perform Detailed Fatigue Analysis and Safe-Life Analysis
- 506 Perform Engineering Analysis to Determine Disposition
- 507 Remove From Service and Finalize Disposition
- 508 Derate Vessel to MOP + 10% and Adjust Relief Valves
- 509 Calculate Remaining Safe-Life Based on Corrosion Rate
- 510 Perform Engineering Analysis to Estimate Corrosion Damage and Remaining Safe-Life
- 511 Calculate Remaining Safe-Life Based on Creep Rate
- 512 Perform Engineering Analysis to Estimate Creep Damage and Remaining Safe-Life
- 513 Calculate Safe-Life Based on Additional Failure Mode
- 514 Compare Safe-Life as Predicted by Failure Mechanisms
- 515 Choose Most Limiting Safe-Life

- 516 Define Recertification Period Equal to 20 Years
- 517 Define Recertification Period Equal to Remaining Safe-Life
- 518 Develop Inservice Inspection Plan Based on Recertification Period
- 519 Resolve all Outstanding Concerns and Establish MAWP and Service Restrictions
- 520 Establish Overpressurization Protection Requirements
- 521 Establish Date for Next Recertification and Initiate ISI

RECERTIFICATION GUIDE

**ACTIVITY
NUMBER**

101

PHASE I, Documentation Retrieval, Review and Assessment

ACTIVITY: Perform Survey of Vessel

PURPOSE: To obtain preliminary information directly from the vessel to be evaluated, designating identification numbers and available markings.

DESCRIPTION: The nameplate of a vessel always contains significant information which can be used to obtain manufacturer's data (reports, drawings, specifications, etc.), fabrication details, and maximum allowable working pressure and temperature values.

STEPS WITHIN THE ACTIVITY:

1. Copy all information from all nameplates attached to vessel or support structure (two or three nameplates may be attached to cryogenic vessels or vessels which have been modified).
 2. Complete "Nameplate Data Review Form" with details on vessel configuration and available overpressurization protection.

MAJOR OBSTACLES: Vessel nameplates may be difficult to read and may require the use of a rubbing (using a paper overlay and rubbing with a colored substance) to define all data contained.

MAJOR DECISIONS: None

INPUT: Copy of "Nameplate Data Review Form."

OUTPUT: Completed "Nameplate Data Review Form."

RELATED ACTIVITIES: 102, 103

SAMPLE REFERENCES: None

NUCLEAR VESSEL NAME PLATE DATA REVIEW

VEHICULAR LOCATION _____

REGULATORY LOCATION _____

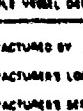
CONTENTS CHARACTERISTICS _____

NUCLEAR VESSEL DESIGNATION _____

MANUFACTURED BY _____

MANUFACTURER'S LOCATION _____

MANUFACTURER'S SERIAL NUMBER _____



MATERIAL ALLOWABLE PRESSURE _____ PS AT _____ °F

DESIGN PRESSURE _____ PS DESIGN TEMPERATURE _____ °F

HYDROSTATIC TEST PRESSURE _____ PS

CRUSHION ALLOW _____ PS

DIA. DIAMETER _____ IN LENGTH _____ IN

SHELL THICKNESS _____

HEAD THICKNESS _____

NAMEPLATE BOARD NO. _____

YEAR BUILT _____

ADDITIONAL INFORMATION

TYPE OF TANK: HORIZONTAL OR VERTICAL TOWER

DESIGN FEATURES

Safety valve outlets NUMBER: _____ TYPE: _____

PSI: _____ LOCATION: _____

Support: (WGT. TON NO. LOAD PSF) _____ LOAD PSF: _____

Other comments: _____ ATTACHED: _____

REMARKS

NAME: _____ DATE: _____

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: I, Documentation Retrieval Review and Assessment

102

ACTIVITY: Retrieve and Review of Operations Documentation

PURPOSE: To establish operating history for the vessel including cycling frequencies and normal operating pressure, temperature and conditions.

DESCRIPTION: The accumulation of operating history for the vessel is used in both the engineering evaluation and establishment of NDE for assessment of the vessels structural integrity.

STEPS WITHIN THE ACTIVITY:

1. Discuss operating history with operational, maintenance, and engineering staff, document results of conversation(s).
2. Review operating logs and operating procedures, obtain copies if available.
3. Document any unusual or abnormal transients in pressure, temperature, vibration, etc.
4. Key areas to address with operating personnel include:
 - Operation exceeding the design parameters (typically temperature and/or pressure)
 - Expected service (e.g., increasing cycling duty, new applications, commodities, configurations)
 - Failure history

MAJOR OBSTACLES: Detailed operating histories for vessels are not often obtainable, on-site staff is typically only source of historical information.

MAJOR DECISIONS: Assess the credibility and accuracy of operating histories obtained from personnel interviews.

INPUT: Operating logs, procedures, or historical documentation from cognizant site personnel.

OUTPUT: Summary of operating history.

RELATED ACTIVITIES: 101

SAMPLE REFERENCES: None

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

103

PHASE: I, Documentation Retrieval, Review and Assessment

ACTIVITY: Retrieve and Review of Maintenance Documentation

PURPOSE: To establish maintenance history for the vessel including history of refurbishment, inspections and tests, repairs, modifications, and problem reports.

DESCRIPTION: The accumulation of maintenance history for the vessel is used to document modifications and repairs which may have been made in the past, including repairs due to previous unsatisfactory inspection or test results.

STEPS WITHIN THE ACTIVITY:

1. Obtain and review maintenance/repair log, if available.
2. Review work orders for maintenance activities, document normal and repair/modification activities.
3. Discuss maintenance history with cognizant personnel with emphasis on modifications, repairs, inspections/tests, and routine inspections/tests of overpressurization protection devices, document conversations.

MAJOR OBSTACLES: Detailed maintenance histories for vessels are not often easily obtainable, review of work orders may be time consuming, requiring on-site staff support.

MAJOR DECISIONS: Assess the credibility and accuracy of operating histories obtained from personnel interviews.

INPUT: Maintenance logs, work orders, or historical documentation from cognizant site personnel.

OUTPUT: Summary of maintenance history.

RELATED ACTIVITIES: 101, 102

SAMPLE REFERENCES: National Board Inspection Code, ANSI/NB-23

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: I, Documentation Retrieval Review and Assessment

104

ACTIVITY: Retrieve and Review of Engineering Documentation
(Coded Vessels)

PURPOSE: To establish original engineering design specification and configuration, along with code of record (code or standard title, year, edition, addenda, applicable code cases, etc.) and history of modifications and repairs including specifications, records, or drawings.

DESCRIPTION: The accumulation of the original manufacturer's data report, design and/or construction drawings, engineering specifications, design calculations, and modification/repair drawings assists the certification/recertification team throughout the project.

STEPS WITHIN THE ACTIVITY:

1. Using the manufacturer's serial number, obtain specifications, drawings, and calculations from site files (user organization, civil engineering or real property office, or other cognizant organization) or from original manufacturer.
2. Obtain original manufacturer's data report from site files, original manufacturer or National Board of Boiler and Pressure Vessel Inspectors (with N.B. number).
3. Obtain drawings and/or specifications for modifications/repairs.

MAJOR OBSTACLES: Many organizations may be required to be contacted to obtain sufficient documentation; cost may be incurred to obtain data reports, drawings, etc.

MAJOR DECISIONS: Extent of search for documentation, a balance between cost, time, and probability of obtaining documentation must be assessed.

INPUT: Serial number, National Board number, facility number or other identification number from nameplate.

OUTPUT: Copies of drawings, specifications, data reports, calculations, and other engineering documentation.

RELATED ACTIVITIES: 101

SAMPLE REFERENCES: (1) National Board Inspection Code, ANSI/NB-23
(2) ASME Boiler & Pressure Vessel Code, Section VIII,
Divisions 1 and 2

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: I, Documentation Retrieval Review and Assessment

105

ACTIVITY: Retrieve and Review of Engineering Documentation
(Non-Coded Vessels)

PURPOSE: To establish original engineering design specification and configuration, along with history of modifications and repairs, including specifications, records, or drawings.

DESCRIPTION: Typically the primary source of documentation on non-coded vessels is the original design specification and manufacturer's drawings, additional information may be available if the original specification required its development and transmittal with the vessel.

STEPS WITHIN THE ACTIVITY:

1. Using nameplate data, review site files (user organization, civil engineering and real property office, or other cognizant organization) to obtain specification, original drawings, and other information as available.
2. Contact original manufacturer using serial number and obtain original drawings, calculations, and associated documentation, as available.

MAJOR OBSTACLES: Information on non-coded vessels may be more limited than coded vessels; the level of available documentation is directly related to original requirements in specification.

MAJOR DECISIONS: Extent of search for documentation, a balance between cost, time, and probability of obtaining documentation must be assessed.

INPUT: Serial number, original contract or job number.

OUTPUT: Copies of drawings, specifications, calculations, and other engineering documentation.

RELATED ACTIVITIES: 101

SAMPLE REFERENCES: None

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: I, Documentation Retrieval Review and Assessment

106

ACTIVITY: Establish Configuration Baseline File for Vessel.

PURPOSE: To establish a baseline file for current vessel configuration along with documented historical engineering, operations and maintenance information.

DESCRIPTION: All vessel information is assembled and assessed for completeness and consistency, missing or inconsistent information is summarized for emphasis in follow up activities.

STEPS WITHIN THE ACTIVITY:

1. Compare current configuration with original documentation, along with record of modifications and repairs, to assess consistency; note discrepancies.
2. Note significant operational or maintenance activities which could have resulted in excessive stresses (both residual or cyclic).

MAJOR OBSTACLES: Much information may be missing for adequate assessment.

MAJOR DECISIONS: A preliminary list of concerns must be established based on documentation contained in baseline file.

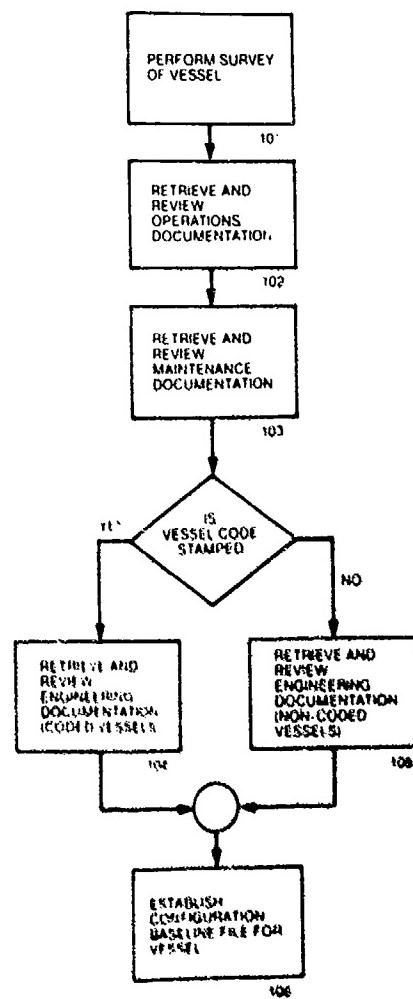
INPUT: Engineering, operational, maintenance documentation.

OUTPUT: List of preliminary concerns requiring detailed review and assessment.

RELATED ACTIVITIES: 102, 103, 104, 105

SAMPLE REFERENCES: Air Force Regulation 65-3, "Configuration Management".

**PHASE I: DOCUMENTATION RETRIEVAL
AND REVIEW**



RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: II, Engineering Assessment

201

ACTIVITY: Assess Vessel Configuration and Operation using Agency Requirements

PURPOSE: To evaluate the current vessel configuration against current Agency requirements stated in applicable regulations, military standards, and manuals.

DESCRIPTION: A comparison is made between current vessel configuration and requirements in regulations (e.g. ESMC regulation 127-1), military standards (e.g. MIL-STD-1522), Air Force Manuals (e.g. AFM 88 Series), and associated documents, to determine compliance.

STEPS WITHIN THE ACTIVITY:

1. Using a checklist of requirements for all applicable Agency regulations, standards, and manuals, evaluate compliance of current pressure/cryogenic vessel configuration.
2. Organize discrepancies under (1) immediate safety concerns, (2) ordinary safety concerns and (3) configuration management (CM) concerns. Document all discrepancies.
3. Immediately report safety concerns of an imminent nature to the operational staff and the safety office; report other safety concerns to the safety office as quickly as practical, all other concerns over configuration management are reported during routine briefings. "Out of service" vessels to be returned to an operational status requires special safety office attention and approval.

MAJOR OBSTACLES: None

MAJOR DECISIONS: Immediate action on imminent safety concerns.

INPUT: Copies of all Agency requirements for Pressure Vessels.

OUTPUT: List of Agency requirements discrepancies.

RELATED ACTIVITIES: 202

SAMPLE REFERENCES:

1. ESMC Regulation 127-1, "Range Safety Manual"
2. TO 00-25-223
3. MIL-STD-1522 (current revision), "Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems."
4. Air Force Manual, AFM 88 Series, "Facility Design and Planning."

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: II, Engineering Assessment

202

ACTIVITY: Assess Vessel MAWP using ASME
Boiler & Pressure Vessel Code, Section VIII,
Division 1

PURPOSE: To evaluate the current vessel design configuration against current national consensus codes and standards.

DESCRIPTION: A comparison is made between the current configuration and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (B&PV) Section VIII, Division 1, or other applicable standard. This activity involves the preliminary evaluation of engineering conformance to the design and construction standards and thus does not require review against Section VIII, Division 2.

STEPS WITHIN THE ACTIVITY:

1. List all design parameters for current vessel configuration as determined from documentation.
2. Using the current edition and addenda of the ASME B&PV Code, Section VIII, Division 1, or other appropriate standard, calculate current requirements for vessel configuration and Maximum Allowable Working Pressure (MAWP). List all configuration, material, or MAWP discrepancies requiring further investigation; if no discrepancies exist report details of investigation and MAWP for operation.

MAJOR OBSTACLES: All design parameters may not be available and in-field measurements may be required.

MAJOR DECISIONS: Assumptions may be required for some design parameters, conservatism is advised.

INPUT: Drawings, data reports, specifications, in-field measurements.

OUTPUT: List of discrepancies compared to the appropriate national consensus standards.

RELATED ACTIVITIES: 201

SAMPLE REFERENCES:

- (1) ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 (current edition and addenda).
- (2) American Petroleum Institute (API) Standard 620, "Recommended Rules for Design and Construction of Large, Welded, Low Pressure Storage Tanks."
- (3) API 650, "Welded Steel Tanks for Oil Storage, Atmospheric Tanks."

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: II, Engineering Assessment

203

ACTIVITY: Assess Vessel MAWP using ASME Boiler and Pressure Vessel Code, Section VIII, Division 2

PURPOSE: To evaluate the current vessel design configuration against Section VIII, Division 2.

DESCRIPTION: Section VIII, Division 2 allows a 3:1 safety factor on ultimate tensile strength, therefore permitting a higher MAWP for a given wall thickness and configuration. It, however, requires a greater level of analysis and inspection, including stress and fatigue analysis and volumetric examinations. Details on material properties and weld configurations are necessary to evaluate vessel stresses under Division 2.

STEPS WITHIN THE ACTIVITY:

1. List all design parameters for current vessel configuration as determined from data reports, drawings or other related documentation. Obtain material specifications for all vessel materials.
2. Using the current edition and addenda of the ASME B&PV Code, Section VIII, Division 2, calculate current requirements for vessel configuration and MAWP. Special attention should be paid to discontinuity stresses, reinforcement, fatigue life, and other vessel-specific concerns such as residual stress.
3. List all configuration, material, or MAWP discrepancies requiring further investigation; if no discrepancies exist, report details of investigation and MAWP for operation.
4. List follow-up inspections/tests required to confirm analysis and/or justify recertification to Division 2 rules.

MAJOR OBSTACLES: All design parameters may not be available and conservative estimates may be required.

MAJOR DECISIONS: Applicability of Section VIII, Division 2 analysis to the vessel under investigation, since certain configurations are not permitted by Division 2.

INPUT: Drawings, data reports, specifications.

OUTPUT: List of discrepancies and required inspections as required by comparison to Division 2.

RELATED ACTIVITIES: 202.

SAMPLE REFERENCES: ASME Boiler & Pressure Vessel Code, Section VIII, Division 2 (current edition and addenda).

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

204

PHASE: II, Preliminary Engineering Assessment

ACTIVITY: Derate Vessel to Calculated MAWP

PURPOSE: To establish a MAWP consistent with design analysis performed to current national consensus codes and standards.

DESCRIPTION: Since technological advances have occurred since manufacture of the vessel, increased knowledge of design, fabrication or service environments may indicate that a reduction in MAWP may be necessary to maintain the required level of safety during the next recertification period.

STEPS WITHIN THE ACTIVITY:

1. Establish MAWP based on current design code.
2. Mark new MAWP on vessel adjacent to current nameplate (do not deface current nameplate), including indication of code.
3. Update instructions, procedures, or other operating documentation to reflect new MAWP.

MAJOR OBSTACLES: Interaction with the operating staff may require numerous contacts to assure compliance with lower MAWP.

MAJOR DECISIONS: The reduction in MAWP may be scheduled over a period of time to allow for operational adjustments.

INPUT: MAWP from design analysis.

OUTPUT: Updated operational documents and vessel markings.

RELATED ACTIVITIES: 202, 203.

SAMPLE REFERENCES: National Board of Boiler & Pressure Vessel Inspectors, National Board Inspection Code (current edition).

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

205

PHASE: II, Engineering Assessment

ACTIVITY: Evaluate Overpressurization Protection
Using ASME and Agency Requirements

PURPOSE: To provide appropriate relief protection for the vessel through the evaluation of Agency requirements and national consensus standards.

DESCRIPTION: Overpressurization protection provides a mechanism to limit overpressurization transients by setting relief devices at MAWP, accounting for maximum flowrate of the system.

STEPS WITHIN THE ACTIVITY:

1. Review overpressurization protection configuration using Agency requirements.
2. Using current ASME B&PV Code, Section VIII evaluate overpressurization protection requirements.
3. List discrepancies between current configuration and requirements.

MAJOR OBSTACLES: Documentation on non-code relief devices is sometimes limited, manufacturer contacts may be required.

MAJOR DECISIONS: None.

INPUT: Documentation on relief devices, nameplate data, configuration drawings.

OUTPUT: List of discrepancies and follow-up actions.

RELATED ACTIVITIES: 204.

SAMPLE REFERENCES: ASME B&PV Code, Section VIII.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: II, Engineering Assessment

206

ACTIVITY: Adjust Relief Valves to Acceptable Setting

PURPOSE: To establish overpressurization protection for the vessel.

DESCRIPTION: The maximum primary relief protection should be set no higher than MAWP, recognizing that MOP will be established below this value to prevent inadvertent actuation of relief devices.

STEPS WITHIN THE ACTIVITY:

1. Reset primary relief device to a maximum of MAWP, documenting change in procedures, instructions, and other operating documentation.

MAJOR OBSTACLES: Interaction with the operating staff may require numerous contacts to assure compliance with MAWP relief setting.

MAJOR DECISIONS: None.

INPUT: MAWP from vessel calculations.

OUTPUT: Documentation on relief setting.

RELATED ACTIVITIES: 205.

SAMPLE REFERENCES: ASME Boiler & Pressure Vessel Code, Section VIII.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

207

PHASE: II, Engineering Assessment

ACTIVITY: Review and Assess Fabrication
(Materials and Welding) vs. Lessons Learned

PURPOSE: To evaluate the vessels original fabrication (materials and welding) requirements against current practice.

DESCRIPTION: Since many vessels used by government and industry were manufactured from 20 to 40 years ago, materials and welding considerations may have changed due to increased understanding or as a result of failures.

STEPS WITHIN THE ACTIVITY:

1. Determine whether material specification for base metal is approved by ASME or the American Society for Testing and Materials (ASTM) and whether changes have occurred since original manufacture due to changes in technology.
2. Determine if concerns have been raised over the use of the material (e.g. T-1 Steel) since original manufacture.
3. Determine if concerns have been raised over the welding techniques used in fabrication.
4. List concerns uncovered in investigation.

MAJOR OBSTACLES: Contact is required with ASME and/or ASTM.

MAJOR DECISIONS: Evaluation of material differences.

INPUT: Drawings, specifications, data reports, etc.

OUTPUT: List of material/welding discrepancies/concerns.

RELATED ACTIVITIES: 201, 202, 203

SAMPLE REFERENCES:

1. ASME Boiler & Pressure Vessel Code, Section II, Material Specifications.
2. ASTM Material Specifications.
3. American Welding Society (AWS) Material Specifications.
4. ASME Boiler and Pressure Vessel Code, Section VIII, Divisions 1 and 2.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

208

PHASE: II, Engineering Assessment

ACTIVITY: Evaluate Susceptibility of Metal
to Corrosion

PURPOSE: To evaluate the susceptibility of a metal to corrosion in its operating environment including general corrosion, galvanic corrosion, local corrosion (pitting), intergranular corrosion, crevice corrosion, stress corrosion, or corrosion by soil or insulation.

DESCRIPTION: The susceptibility of a metal to corrosion in a particular environment should be evaluated based on past history. If corrosion is a suspected potential failure mode, no exposed defects should be regarded as acceptable and consideration should be given as to the inherent suitability of the material for the application. Upon review of specific material susceptibility and environmental conditions experienced, recommendations should be made to assess material condition by appropriate NDE technique.

STEPS WITHIN THE ACTIVITY:

1. Determine the metal characteristics and history associated with corrosion susceptibility.
2. Review previous maintenance, inspection, and test records for evidence of corrosion, with attention to local corrosion, intergranular corrosion, crevice corrosion, and stress corrosion.
3. Determine if stress corrosion fracture toughness data (KISCC) for material exists in technical literature.
4. Evaluate potential corrosion susceptibility of metal in operating environment, specify additional inspections and tests as necessary to investigate areas in which deleterious combinations of high tensile stress, environment, and metal characteristics exist.

MAJOR OBSTACLES: The susceptibility of corrosion, and in particular stress corrosion, may or may not be anticipated by test/experiments using the same metal and environment. In-field inspections must be made to confirm concerns when history of susceptibility exists.

MAJOR DECISIONS: Extent of follow-up NDE when corrosion is suspected.

INPUT: Previous historical data and operations and maintenance documentation.

OUTPUT: When appropriate, detailed NDE recommendations to evaluate the location and extent of corrosion damage.

RELATED ACTIVITIES: None.

SAMPLE REFERENCES:

1. Corrosion Source Book, S.K. Coburn, ed, National Association of Corrosion Engineers and American Society for Metals, 1984.
2. Hydrogen Embrittlement and Stress Corrosion Cracking, R. Gibala and R.F. Hehemann, ed, American Society for Metals, 1984.
3. Corrosion and Corrosion Protection Handbook, P.A. Schweitzer, Ed, Marcel Dekker, Inc., 1983.
4. Various military handbooks, manuals from NASA centers such as MSFC and KSC, and other associated military documents.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

209

PHASE: II, Engineering Assessment

ACTIVITY: Review History of Cyclic Operation
or Extraordinary Transients

PURPOSE: To evaluate operating conditions to determine potential of excessive stress or fatigue during lifetime.

DESCRIPTION: There are a number of failure modes associated with stress and fatigue which should be considered including: overpressure, external loading, pressure cycling (both high and low), variations in flow, vibration, thermal cycling, dissimilar metals welds, and high temperature creep. Each should be reviewed on a case-by-case basis for application to the vessel under consideration.

STEPS WITHIN THE ACTIVITY:

1. Determine the operating conditions for the vessel (e.g. approximate number of lifetime pressure and temperature cycles; history of overpressure; history of significant flow transients; vibration, especially vessels associated with rotating machinery; creep, especially in operating temperatures above 700°F; and dissimilar metal welds).
2. Develop list of concerns associated with any of these possible failure mechanisms.
3. Evaluate potential for failure and develop NDE plan to further investigate potential areas for failure initiation.

MAJOR OBSTACLES: Collection of historical information.

MAJOR DECISIONS: Establishment of conservative estimates on historical operating environment may be required when minimal data is available.

INPUT: Summary of operating history, including review of maintenance history to assess recovery from extraordinary transients or abnormal operation.

OUTPUT: Recommendations on further analysis, NDE, or destructive testing.

RELATED ACTIVITIES: 102, 103.

SAMPLE REFERENCES:

1. Defects and Failures in Pressure Vessels and Piping, H. Thielsch, R.E. Kruger Publishing Co., New York, 1975.
2. Metals Handbook, Volume II, Failure Analysis and Prevention, American Society for Metals, 1986.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

210

PHASE: II, Engineering Assessment

ACTIVITY: List Discrepancies and Concerns
from Reviews, Evaluations and Assessments

PURPOSE: To compile a list of discrepancies which resulted from all previous activities.

DESCRIPTION: An extensive review has been conducted, potentially resulting in several major and numerous minor discrepancies. A compilation is required to assist in setting priorities on the resolution of the discrepancies.

STEPS WITHIN THE ACTIVITY:

1. Review all information developed in previous activities.
2. Group discrepancies of a similar nature.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: Reports from previous activities.

OUTPUT: List of discrepancies and concerns.

RELATED ACTIVITIES: 100 and 200 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

211

PHASE: II, Engineering Assessment

ACTIVITY: Retain Concerns in File for Reference

PURPOSE: To document those discrepancies which do not require follow-up action.

DESCRIPTION: The establishment of a file on each vessel requires that all documentation generated as part of the recertification process be included.

STEPS WITHIN THE ACTIVITY:

1. Summarize discrepancies which do not require follow-up action and file in vessel documentation.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: Reports from previous activities.

OUTPUT: Output for file.

RELATED ACTIVITIES: 210.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

PHASE: II, Engineering Assessment

212

**ACTIVITY: Establish List of Discrepancies by Priority
(Immediate, Short Term, Long Term)**

PURPOSE: To evaluate discrepancies found in previous activities and establish a priority list for follow-up action to resolve concerns.

DESCRIPTION: The engineering assessment has resulted in a list of concerns requiring follow-up engineering analysis, inspection/tests, modifications/corrective action, or destructive examination. Attention should be placed first on those discrepancies of an immediate (less than one week) safety concern. These would be followed by discrepancies which may be addressed over a short-term (one week to three months) or long-term (four months to several years). Immediate safety concerns may include concerns found during any of the phases of this program. For example, the documentation review may find components undersized (e.g., a water fitting in a high pressure gas system); the system walkdown may find relief protection isolated from the system; or the engineering assessment may find a component or vessel to be significantly under designed. Each of these situations may require immediate notification of safety and operational personnel to correct safety concern. Generally, a short-term concern may be found during any of the phases of the program; however, it does not involve a safety issue which may endanger life or property if not immediately acted upon. Examples may include significant deviation between documentation and actual configuration; concerns associated with material compatibility; or concerns associated with adequacy of supports or attachments. Short-term concerns may require follow-up engineering analysis, inspection or testing and informing of safety or operational personnel. Long-term concerns are typically associated with minor discrepancies between documentation and actual configuration, minor engineering concerns, or other discrepancies not expected to have a safety impact on personnel or the facility. It should be evident that the evaluation and resolution of concerns depends on engineering, operational, and safety organizations cooperation and timely addressing of both safety and non-safety related matters.

STEPS WITHIN THE ACTIVITY:

1. List concerns requiring follow-up action along with required actions and objectives.
2. Develop a plan to address each concern in appropriate order, as required by engineering and operational constraints. The plan should include a summary of the concerns, objectives to be met to resolve concerns, responsible organizations, schedule, and milestones.
3. Resolve problems between safety, operational, and engineering constraints, implement plan addressing concerns.

MAJOR OBSTACLES: Coordination will be required with operational staff to determine schedules.

MAJOR DECISIONS: Resolution of immediate and short term concerns will have the highest priority and thus decisions on safety and operational impact must take place.

INPUT: Previous analysis and list of concerns.

OUTPUT: Action plan for follow-up activities.

RELATED ACTIVITIES: 210.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

**ACTIVITY
NUMBER**

213

PHASE: II, Engineering Assessment

ACTIVITY: Address Concerns with Immediate Priority

PURPOSE: To resolve immediate safety concerns to satisfactorily protect personnel and equipment.

DESCRIPTION: A number of concerns raised during the engineering assessment may require immediate attention due to safety issues such as pressure/temperature ratings, relief device setting, support requirements, or material/fabrication discrepancies. Such concerns which may result in immediate safety hazard should be addressed as soon as practicable or actions taken to alleviate the possibility of personnel injury or equipment damage if failure were to occur. Analysis may be immediately required to address engineering concerns (fatigue, fracture properties), material (corrosion, erosion), or fabrication (welding or base metal defects).

STEPS WITHIN THE ACTIVITY:

1. Address each concern of immediate priority.
2. Resolve concern or implement action to prevent personnel injury or equipment damage.
3. Report results to cognizant safety and operational personnel.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: List of concerns requiring immediate attention.

OUTPUT: List of actions required to resolve concern.

RELATED ACTIVITIES: 212.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

214

PHASE: II, Engineering Assessment

ACTIVITY: Remove from Service and Establish
"Return to Service" Plan (as applicable)

PURPOSE: To remove from service those vessels with unresolved major safety concerns and establish (as applicable) a plan to resolve concerns and return vessel to service.

DESCRIPTION: A vessel may require removal from service to resolve safety concerns which cannot be addressed while in service or appears to present a safety hazard which cannot be addressed through restriction of access or modification of operation. If a vessel must be removed from service, a "return to service" plan should be developed to address the concerns and attempt to return the vessel to operational service. If concerns cannot be resolved, then the vessel should be permanently removed from service.

STEPS WITHIN THE ACTIVITY:

1. Working with operating staff and under cognizance of safety representative, remove vessel from service.
2. Develop plan to resolve concerns and develop tentative schedule for return to service. The plan and schedule, as a minimum, should include: (1) list of concerns and plan of action necessary to address each concern, (2) milestones and schedule to meet operational requirements, (3) decision points at which approvals should be obtained to proceed (i.e., decision points associated with major expenditures for inspection/testing or repair/modifications), (4) items which may delay or cancel the return to service plan, and (5) points of contact for management and coordination of the program.

MAJOR OBSTACLES: Close interaction between operating and safety personnel is necessary.

MAJOR DECISIONS: None.

INPUT: List of concerns requiring resolution.

OUTPUT: "Return to Service" Plan.

RELATED ACTIVITIES: None.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

215

PHASE: II, Engineering Assessment

ACTIVITY: Address Concerns with Short and Long Term Priority

PURPOSE: To address routine safety concerns and configuration management concerns raised during the engineering assessment.

DESCRIPTION: A number of concerns raised during the engineering assessment may involve routine safety issues (such as labelling of commodities or other items which does not immediately present a hazard to personnel or equipment) or configuration management issues (such as inaccurate drawings, tagging, or other documentation). Other short- or long-term engineering, material or fabrication concerns should be addressed in appropriate depth to assist in selection of required NDE and/or decisions on follow-up actions.

STEPS WITHIN THE ACTIVITY:

1. Using priorities, establish list of concerns in order of required resolution.
2. Address each concern.
3. Report results to cognizant safety and operational personnel.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Order in which concerns are addressed and timeliness of resolution.

INPUT: Analysis from previous engineering assessments.

OUTPUT: Required actions to resolve concerns.

RELATED ACTIVITIES: 200 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: II, Engineering Assessment

216

ACTIVITY: Establish Engineering and/or
Inspection/Test Objectives

PURPOSE: To develop objectives for follow-up engineering analysis or inspection/tests.

DESCRIPTION: The resolution of concerns or the confirmation of engineering assumptions forms the basis of the establishment of the objectives for follow-up engineering or inspection/tests. The objectives include a summary of the information required to be obtained from follow-up actions. As a minimum, the objectives should include confirmation of wall thickness for all plates, nozzles, etc.; overall configuration; repairs or modifications; and overpressurization protection. In addition, if concerns include material corrosion or incompatibility, special inspections should be designed to confirm problems or the lack of problems. Follow-up engineering (stress analysis, fatigue (pressure, temperature) analysis, or fracture mechanics analysis) may also be required. Follow-up inspections may include evaluation of volumetric integrity of the full penetration welds, including heat affected zones, evaluation of partial penetration support or attachment welds (volumetric or surface examination), or the implementation of proof testing or cryogenic - shock testing (for cryogenic liquid vessels). The objectives developed should include criteria for successful resolution of concerns, that is, minimum wall thickness, code/standard acceptance criteria for nondestructive examination, etc.

STEPS WITHIN THE ACTIVITY:

1. Using engineering assessments, list of concerns and engineering assumptions, develop objectives for follow-up actions.
2. Assure objectives include criteria for resolution of concerns.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: Engineering assessments.

OUTPUT: Objectives for follow-up action.

RELATED ACTIVITIES: 100 and 200 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: II, Engineering Assessment

217

ACTIVITY: Perform Additional Engineering Analysis

PURPOSE: To perform additional engineering analysis (as applicable) to address any issues raised as part of assessment of engineering concerns prior to developing inspection/test plan.

DESCRIPTION: Additional issues may be raised as part of the assessment of immediate, short - and long-term concerns. These issues may require additional engineering analysis prior to the establishment of the inspection/test plan. The engineering analysis should be performed prior to this plan development when conclusions could impact required inspections or tests.

STEPS WITHIN THE ACTIVITY:

1. Define additional required engineering analysis.
2. Perform that analysis required prior to development of inspection/test plan. This may require finite element analysis of critical welds (head to shell, nozzle or head) or other penetrations; evaluation of material properties or welding procedures; or other associated fabrication concerns.
3. Schedule additional analysis, as necessary.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

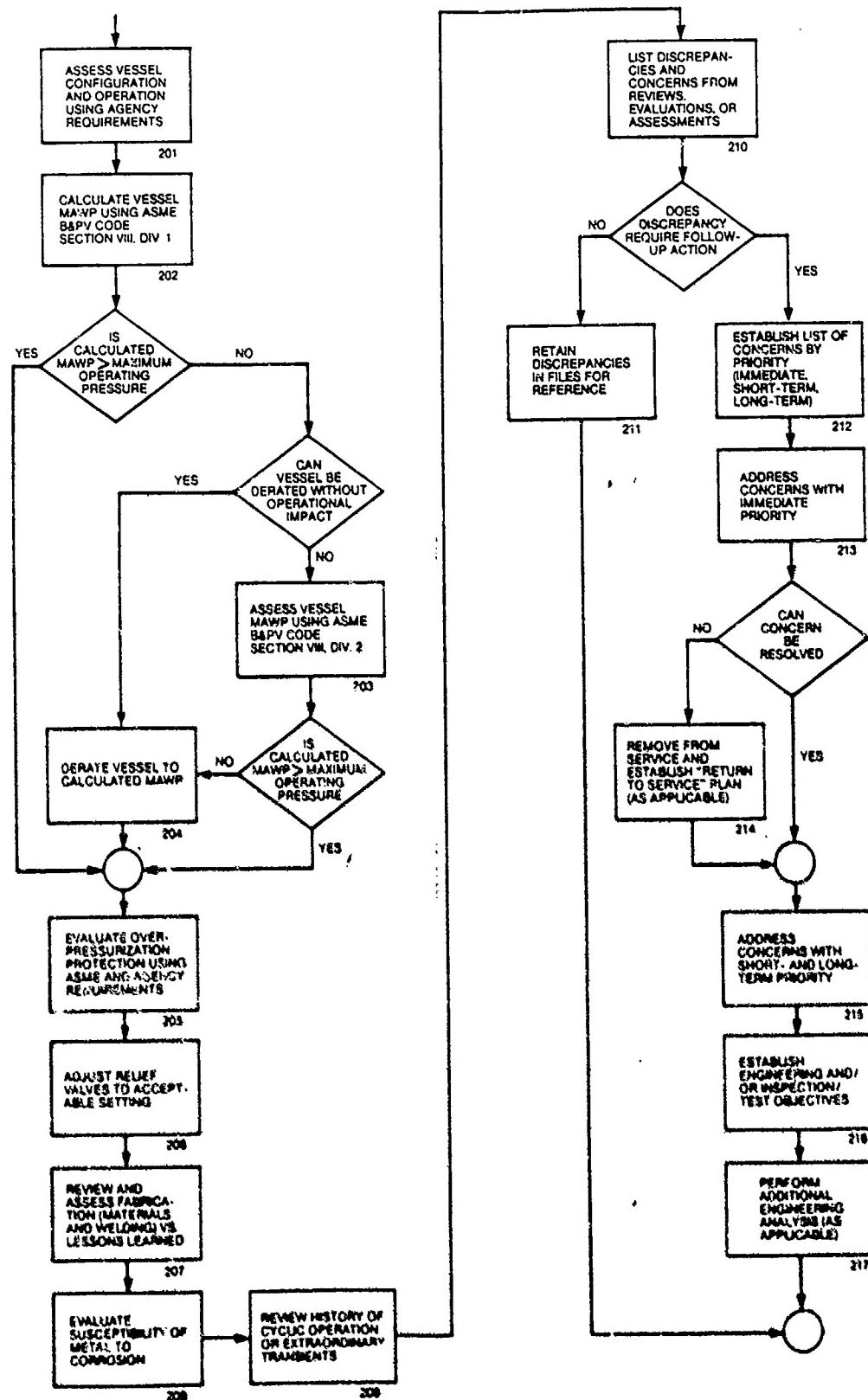
INPUT: Engineering assessments.

OUTPUT: List of unresolved concerns.

RELATED ACTIVITIES: 200 series.

SAMPLE REFERENCES: None.

PHASE II: ENGINEERING ASSESSMENT



RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: III, Inspection/Testing Plan

301

ACTIVITY: Define Inspection and Testing Requirements
to Resolve Concerns

PURPOSE: To develop inspection/test requirements to confirm design parameters and resolve preliminary engineering or fabrication concerns.

DESCRIPTION: Inspection/test requirements included a basic group of inspections/tests to confirm design parameters and additional tests/inspections to resolve concerns. Optimizing information obtained from additional inspections/tests is necessary to minimize impact on facility operation. The more confidence the engineer has with the review of preliminary documentation and engineering analysis, the less inspections/tests would be required. Typical inspections include radiography, ultrasonics, magnetic particle, and liquid penetrant exams. Other specialized exams such as acoustic emissions, eddy current, and leak testing may be prescribed on a case by case basis. Proof tests using hydrostatics or pneumatics should also be prescribed. If pneumatics proof tests are used, additional care should be taken to assure safety of personnel and equipment.

STEPS WITHIN THE ACTIVITY:

1. Define extent of internal and/or external visual inspections.
2. Define extent and location for ultrasonic thickness examinations.
3. Define proof test pressure/temperature requirements and restrictions.
4. Define extent and location for additional inspection testing required to resolve concerns (e.g. surface or volumetric exams).
5. Develop acceptance criteria as appropriate to analysis and code/standard requirements from previous activities.

MAJOR OBSTACLES: Operational constraints may limit access.

MAJOR DECISIONS: Selection of appropriate examinations and tests.

INPUT: List of discrepancies requiring follow up action.

OUTPUT: Inspection/test requirements.

RELATED ACTIVITIES: 302

SAMPLE REFERENCES:

1. ASME Boiler & Pressure Vessel Code, Section V and VIII, Divisions 1 and 2.
2. National Board Inspection Code, ANSI/NB-23
3. Compressed Gas Association Standards C-6, "Standards for Visual Inspection of Compressed Gas Cylinders;" G-5.1 and 5.2 on Gaseous and Liquid Hydrogen; and S-1.2 on Safety Relief Device Standards.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

302

PHASE: III, Inspection/Testing Plan

ACTIVITY: Conduct Field Verification of Inspectability

PURPOSE: To determine if required inspections/tests will require special or temporary modifications to configuration or operation.

DESCRIPTION: Many pressure vessels were not manufactured to be inspected/tested after installation, therefore special steps may be required to obtain results. Many pressure vessels were fabricated with: (1) attachments welded over full penetration welds, (2) attachments positioned which prevent easy access to welds, (3) nonremovable insulation covering exterior or interior surfaces, (4) vessels located in close proximity with other vessels or piping/components as to prevent access to surfaces, and (5) vessels located in restricted confinements such as small rooms or spill prevention containments. Many of these items may prevent resolution of concerns requiring the development of alternate approaches. Alternate approaches may include substitution of one NDE technique for another, replacement of proof tests for NDE or substitution of volumetrics for surface exams.

STEPS WITHIN THE ACTIVITY:

1. Walk down vessel with inspection/test requirements to determine (a) any access limitations, (b) operational limitations, (c) configuration limitations, (d) other limitations.
2. List recommendations on (a) alternate inspections/tests, (b) special or temporary modifications.

MAJOR OBSTACLES: None

MAJOR DECISIONS: In-field assessment of alternatives or special requirements.

INPUT: Inspection/test requirements from Activity 301.

OUTPUT: Inspection/test requirements with recommendations on special or temporary modifications.

RELATED ACTIVITIES: 301

SAMPLE REFERENCES: None

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

303

PHASE: III, Inspection/Testing Plan

ACTIVITY: Develop Inspection/Test Procedures
and Acceptance Criteria

PURPOSE: To develop inspection/test procedures with specific guidance on equipment to be used and area/systems to be inspected/tested.

DESCRIPTION: Inspection/Test procedures are developed to address specific aspects of equipment used and vessels inspected or tested, along with applicable acceptance criteria. Personnel performing the development of procedures and acceptance criteria should be qualified and certified as a Level III in volumetric and surface NDE, as described in ASNT SNT-TC-1A.

STEPS WITHIN THE ACTIVITY:

1. Review vessel - specific inspection/testing requirements.
2. Develop acceptance criteria for indications isolated during inspections.
3. Develop procedures as appropriate to inspections and tests, with specific reference to equipment to be used for the examination or test.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Development of acceptance criteria applicable to inservice inspection.

INPUT: Inspection/Test Plan.

OUTPUT: Inspection/Test Procedures.

RELATED ACTIVITIES: None.

SAMPLE REFERENCES:

1. ASME Boiler & Pressure Vessel Code, Section V.
2. American Society for Nondestructive Testing (ASNT), Recommended Practice SNT-TC-1A, "Personnel Qualification and Certification in Nondestructive Testing."

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

304

PHASE: III, Inspection/Testing Plan

ACTIVITY: Develop Work Packages

PURPOSE: To develop work packages for NDE and test personnel containing appropriate details on required inspections and tests.

DESCRIPTION: Work Packages must be developed to define specific inspection/tests to be performed, locations to be inspected and reporting requirements.

STEPS WITHIN THE ACTIVITY:

1. Complete work package with appropriate inspection/test requirements and estimated due date.
2. Enter work package number into an open item tracking list until completed.

MAJOR OBSTACLES: Availability of facility due to operational constraints.

MAJOR DECISIONS: None

INPUT: NDE procedures, qualified and certified NDE personnel, inspection/test requirements.

OUTPUT: Work packages.

RELATED ACTIVITIES: 302

SAMPLE REFERENCES: Specific facility/site documentation on requirements and format of work orders should be reviewed and incorporated, as appropriate.

RECERTIFICATION GUIDE

PHASE: IV, Inspection/Test Implementation

ACTIVITY
NUMBER

ACTIVITY: Perform Inspections and Tests

401

PURPOSE: To perform all required inspections/tests.

DESCRIPTION: Inspections and tests are performed and compared to acceptance criteria; unacceptable indications are reported as discontinuities for evaluation and disposition. Indications include cracks, zones of incomplete penetration or fusion, elongated slag inclusions, a group of slag inclusions in a line or rounded indications (porosity). Inspectors should hold Level II or III Certifications, as defined in SNT-TC-1A. A proof pressure test should be performed as part of the test program. As a minimum, a visual exam should be performed in conjunction with, or following , the proof test. For cryogenic vessels, a cryogenic shock test should be performed as part of the test program, following a proof test.

STEPS WITHIN THE ACTIVITY:

1. Perform required inspections/tests, including a proof pressure test. Follow-up inspections should be performed after the proof test to confirm vessel integrity.
2. Compare indications to acceptance standards.
3. Report discontinuities for evaluation as part of inspection/test report.
4. Recommend follow-up inspections as necessary to characterize or isolate indications.

MAJOR OBSTACLES: Scheduling inspections/tests around operational constraints.

MAJOR DECISIONS: Special attention should be paid to areas of corrosion, non-code modifications, and high stress concentrations.

INPUT: Inspection/test plan and work packages from Activity 304.

OUTPUT: Inspection/test report which contains inspection/test results and summary of unacceptable indications.

RELATED ACTIVITIES: 402, 300 series.

SAMPLE REFERENCES:

1. ASME Boiler & Pressure Vessel Code, Section VIII, Divisions 1 and 2, Section V.
2. American Society for Nondestructive Testing (ASNT) Standard SNT-TC-1A.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

402

PHASE: IV, Inspection/Test Implementation

ACTIVITY: Characterize and Analyze Discontinuities

PURPOSE: To analyze reported discontinuities to determine acceptability, follow-up activities, and remaining life.

DESCRIPTION: Many discontinuities do not meet acceptance criteria but may be acceptable in operation due to their location, characteristics, loadings, or surrounding stresses.

STEPS WITHIN THE ACTIVITY:

1. Characterize discontinuities, measurements of, or assumptions on length, width, depth and orientation of flaw should be made.
2. Evaluate discontinuities such as corrosion or erosion using ASME design equations.
3. Analyze, using a linear elastic fracture mechanics approach, the characterized major discontinuities applicable to this approach.
4. Evaluate results of analysis to determine cyclic life remaining, discontinuity growth potential, margins of acceptable safety.

MAJOR OBSTACLES: Finding fracture toughness information on weld or base metals, conservative assumptions may be required to complete analysis.

MAJOR DECISIONS: Values for assumed fracture toughness parameters and historical environment, including cyclic history.

INPUT: Characterized discontinuity, fracture toughness parameters, operational history.

OUTPUT: Evaluation of remaining life of vessel.

RELATED ACTIVITIES: None

SAMPLE REFERENCES: ASME Boiler & Pressure Vessel Code, Section XI, Appendices A and C.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

403

PHASE: IV, Inspection/Test Implementation

ACTIVITY: Perform Engineering Analysis to Determine Disposition

PURPOSE: To establish requirements for action to correct deficiencies or defects isolated as part of the engineering or inspection/test activities.

DESCRIPTION: Results of engineering analysis or inspection/tests may indicate that repairs or modifications (including derating) to the vessel or relief device(s) may be necessary to permit further operation.

STEPS WITHIN THE ACTIVITY:

1. Determine extent of repair or modification required.
2. Consider all alternatives available to facility in instituting the repair or modification.
3. Choose the most cost-effective approach while paying special attention not to degrade safety or impact critical operational constraints.
4. If a significant safety concern is involved with the repair or modification, establish furthest date for completion of repair or modification prior to mandatory removal from service. If currently out of service, assure repair or modification is made prior to returning to service. All information must be documented and maintained.
5. Monitor repair and modification activities to assure compliance with specification or work requests.
6. Schedule and perform follow-up tests and inspections as necessary to meet Air Force requirements.

MAJOR OBSTACLES: Operational constraints may limit access to vessel or relief device(s).

MAJOR DECISIONS: Coordination between repair organization and operational staff may require several logistics decisions including development of specifications, selection of repair organization, scheduling repairs to minimize impact on operational requirements, and schedule follow-up inspections and tests.

INPUT: Repair or modification orders/requests.

OUTPUT: Completed work orders with inspection reports.

RELATED ACTIVITIES: None

SAMPLE REFERENCES: Range Safety Regulations, ESMCR 127-1.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: IV, Inspection/Test Plan Implementation

404

ACTIVITY: Perform Follow-up Engineering and Specify
Additional Inspections and Tests

PURPOSE: To establish additional inspections/tests available for follow-up on unacceptable indications, or to investigate a suspected generic problem.

DESCRIPTION: Follow-up inspections/tests may be necessary to characterize a suspected discontinuity or to further investigate a suspected generic problem found at another location on the vessel.

STEPS WITHIN THE ACTIVITY:

1. Based on findings from initial inspections/tests revise inspection/test plan to include more detailed or complementary examinations (i.e. a visual exam may indicate that follow-up with radiography or ultrasonics is necessary to evaluate possible discontinuity, a replication or boat sample may be necessary to characterize suspected creep, etc.)
2. Provide details on concern and state objective for this additional examination.
3. If destructive examination (e.g. boat sample) is required, provide guidance on required repair welding procedures, along with specification on the sample to be obtained from the destructive exam.

MAJOR OBSTACLES: If destructive exam is required, extensive preparation will be required.

MAJOR DECISIONS: Extent of additional exams necessary, for example, follow-up volumetric examinations may be prescribed to characterize findings from past volumetric or surface exams.

INPUT: Results of initial inspections/tests and analysis.

OUTPUT: Additional Inspection/test report for follow-up action.

RELATED ACTIVITIES: 401, 402

SAMPLE REFERENCES:

1. ASME Boiler & Pressure Vessel Code, Section V and VIII.
2. ASNT Specifications for destructive examination.

RECERTIFICATION GUIDE

**ACTIVITY
NUMBER**

405

PHASE: IV, Inspection/Test Plan Implementation

ACTIVITY: Remove from Service and Finalize Disposition

PURPOSE: To remove unsafe vessels from service.

DESCRIPTION: It may be necessary to permanently remove a vessel from service due to unrepairable defects found during inspections/test or due to confirmation of engineering/material concerns as uncorrectable.

STEPS WITHIN THE ACTIVITY:

1. Notify safety and operational organizations of concern and indicate if imminent safety of personnel or equipment is involved.
2. Remove from service as directed and finalize disposition. Vessel should be "red tagged" as appropriate to meet site safety guidelines and disabled to prevent further unauthorized operations (e.g. drill hole in head or shell, remove key element for operation, etc). Disposition of the vessel should include appropriate requirements or restrictions on removal such as scrapping, selling of vessel to commercial operator for low pressure service, transfer to government surplus, etc. If vessel should not be used in future service, the nameplate should be marked appropriately and the vessel should be permanently labelled to prevent future unauthorized return to service.

MAJOR OBSTACLES: None

MAJOR DECISIONS: Replacement capacity for removed vessel will be required, this may be supplied from portable vessels, storage dewars or alternate sources.

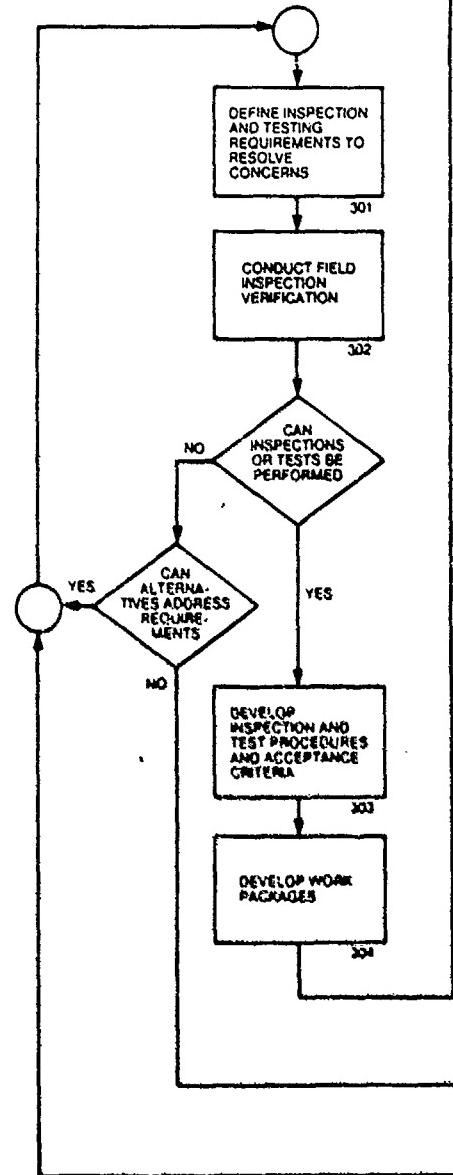
INPUT: Findings from inspections/tests.

OUTPUT: Report on disposition.

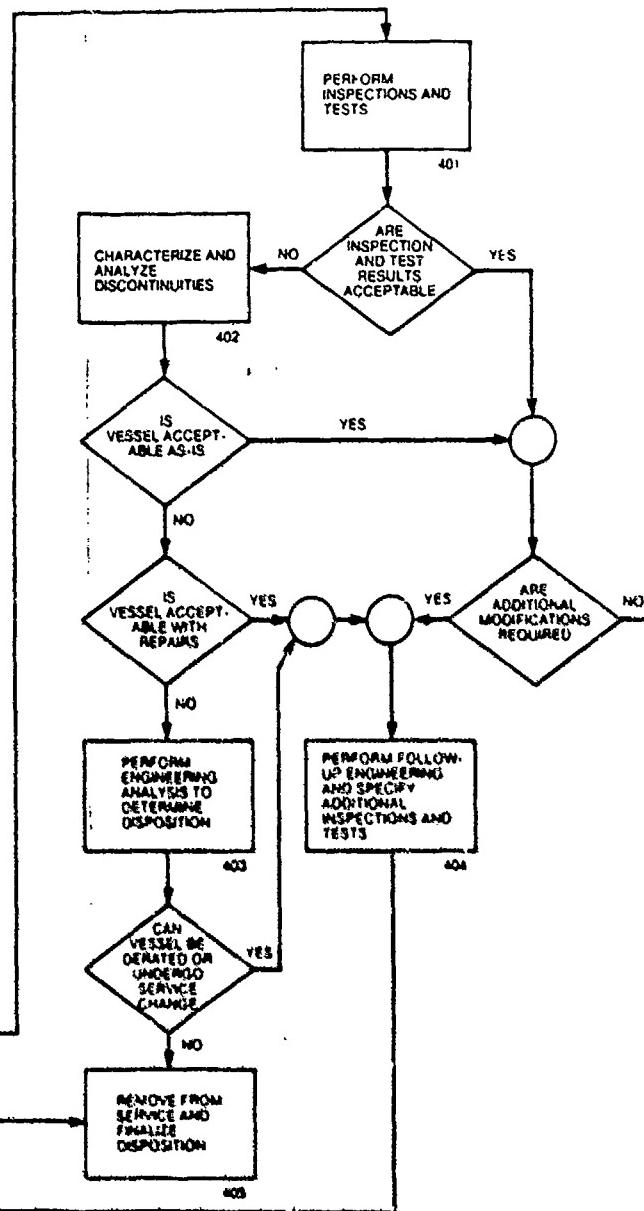
RELATED ACTIVITIES: 401, 402, 403

SAMPLE REFERENCES: None

PHASE III: INSPECTION/TEST PLANNING



PHASE IV: INSPECTION/TEST IMPLEMENTATION



RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: V, Final Evaluation and ISI Initiation

501

ACTIVITY: Determine the Number of Stress Cycles
Per Year Experienced by and Expected for the Vessel

PURPOSE: To establish cyclic history (both pressure and temperature) and project
expected number of cycles per year for immediate and long-term future operation.

DESCRIPTION: Since one of the failure mechanisms of major concern is fatigue, it is
important to establish the number of fatigue cycles experienced in the past and project
an annual estimate for fatigue, since this will be used to project, on the basis of time
(years), the remaining safe-life of the vessel.

STEPS WITHIN THE ACTIVITY:

1. Develop/Define criteria on pressure and temperature cycle counting.
2. Based on documentation, personnel interviews, or operating logs, conservatively
estimate historical cyclic operation, expressed in full stress (pressure, temperature)
cycles.
3. Based on personnel interviews and documentation on future requirements,
conservatively estimate maximum annual cyclic operation.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Limits on pressure or temperature variation which constitutes one
cycle.

INPUT: Documentation, logs, interviews.

OUTPUT: Cyclic history, projected annual cyclic operation.

RELATED ACTIVITIES: 502, 503.

SAMPLE REFERENCES: ASME, Boiler & Pressure Vessel Code, Section VIII, Division 2.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

502

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Perform Detailed Safe-Life Analysis

PURPOSE: To determine the vessel safe-life based on a detailed fatigue analysis.

DESCRIPTION: As part of the recertification process, a detailed fatigue analysis may have been performed. That is, a fatigue analysis in accordance with the rules of ASME B&PV Code Section VIII, Division 2, would provide for the establishment of a cyclic life based on maximum stress cycles (pressure, temperature). Since a portion of that cyclic life has already been expended, it is necessary to calculate the remaining cyclic life (or remaining safe-life) by taking the difference between the calculated cyclic life (based on the detailed fatigue analysis) and the number of stress cycles experienced by the vessel in past operation. This number of cycles can be used to predict future cyclic life or remaining safe-life.

STEPS WITHIN THE ACTIVITY:

1. Based on results from detailed fatigue analysis performed in a previous activity, estimate the safe-life for the vessel.
2. Convert the cyclic life (when applicable) into time (years) to establish the number of years of future operation available for the vessel.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Estimate of future cyclic life based on plans, projections, and personnel/management interviews.

INPUT: Detailed fatigue analysis results.

OUTPUT: Number of years associated with remaining safe-life.

RELATED ACTIVITIES: 203, 501

SAMPLE REFERENCES: ASME Boiler & Pressure Vessel Code Section VIII, Division 2.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

503

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Perform Simplified Safe-Life Analysis

PURPOSE: To determine the vessel safe-life based on a simplified fatigue analysis.

DESCRIPTION: For relatively low cycle vessels, a simplified fatigue analysis procedure is provided to conservatively estimate the total number of fatigue cycles (safe-life) using S-N curves contained in the ASME Boiler & Pressure Vessel Code. This approach may not be appropriate if the vessel contains any of the following features: nonintegral construction, use of pipe threaded connections, stud bolted attachments, partial penetration welds, or major thickness changes between adjacent members. Further screening guidance is provided in the Code. Since a portion of the cyclic life has already been expended, a remaining safe-life calculation is performed.

STEPS WITHIN THE ACTIVITY:

1. Determine the specified minimum ultimate tensile strength for the material(s), define as $3S_m$.
2. Determine whether changes in metal temperature between any two adjacent points in the pressure vessel, including nozzles, exceeds 50°F .
3. Determine (conservatively) the number of past and expected future pressure cycles by the summation of all pressure cycle with amplitudes greater than 20% of the design operating pressure and all thermal cycles meeting requirements in Step 2.
4. Assume S_a equals $3S_m$. Enter the S-N curves presented in Appendix 5 of Section VIII, Division 2 and determine number of cycles, N.
5. Using an average number of past cycles, calculate number of remaining cycles.

MAJOR OBSTACLES: None

MAJOR DECISIONS: Estimation of number of historical fatigue cycles.

INPUT: Historic cyclic service.

OUTPUT: Remaining cyclic life (safe-life as calculated by simplified fatigue analysis).

RELATED ACTIVITIES: 501, 502.

SAMPLE REFERENCES:

ASME Boiler & Pressure Vessel Code, Section VIII, Division 2, Appendix 5 and Part AD-160.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

504

PHASE: V, Final Evaluation and ISI Initiation

**ACTIVITY: Develop Destructive Test Plan to Provide
Detailed Input for Fatigue Analysis or Fracture Mechanics
Analysis**

PURPOSE: To develop and implement destructive tests to provide sufficient information to conduct a detailed fatigue analysis or fracture mechanics analysis.

DESCRIPTION: If the remaining safe-life, as predicted by the fatigue analysis, does not exceed zero (i.e., the fatigue analysis indicates that the vessel is at or has exceeded its design fatigue life), then additional actions may be undertaken to reduce the uncertainty of the data through testing, thus allowing a reduction in conservatism in calculations. A sample may be taken from one or more locations and tested for mechanical and metallurgical properties which may be used to (1) more accurately predict the relationship between alternating stress and number of cycles, (2) construct a vessel specific S-N curve for the vessel under investigation, (3) provide input for fracture mechanics analysis. This approach will also require consideration of weld repairs and associated cost of testing and repair contracts. The cost effectiveness of this approach may be a major consideration prior to proceeding to this activity.

STEPS WITHIN THE ACTIVITY:

1. Based on vessel configuration and engineering information required (i.e. tensile strength, chemical constituents, etc.) prepare a destructive test plan.
2. Conduct the destructive tests as required for fatigue or fracture mechanics analysis.
3. Conduct fatigue testing on material samples of equivalent ASTM specifications to materials destructively tested from the vessel. Test should be in accordance with Section VIII, Division 2, Appendix 6, or equivalent.
4. Prepare report documenting results.

MAJOR OBSTACLES: The cost effectiveness of this approach may be a major consideration.

MAJOR DECISIONS: The extent of destructive testing and optimization of resulting information developed from the tests.

INPUT: Results from fatigue analysis and engineering assessment.

OUTPUT: Test and Repair Plan.

RELATED ACTIVITIES: 100, 200, 400 series, 501, 502, 503.

SAMPLE REFERENCES:

ASME Boiler & Pressure Vessel Code, Section VIII, Division 2, Appendix 6, "Mandatory Experimental Stress Analysis".

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

505

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Perform Detailed Fatigue Analysis or
Fracture Mechanics Analysis and Safe-Life Analysis

PURPOSE: To perform a fatigue analysis or fracture mechanics analysis based on results of destructive tests, fatigue (cyclic loading) tests, or proof pressure test.

DESCRIPTION: The data developed as part of the destructive testing is used to develop vessel (material) specific S-N curves or are used in conjunction with curves in Section VIII, Division 2, Appendix 5. The approach is similar to that presented in Activity 502. As an alternative, a fracture mechanics analysis may be performed using the results of the proof pressure test as the basis of an analysis of remaining cyclic life.

STEPS WITHIN THE ACTIVITY:

1. Using minimum ultimate tensile strength and chemical constituents, determine ASTM specification, and using S-N curves of Appendix 5, determine fatigue life and remaining safe-life (as determined from fatigue analysis).
2. If strain and cyclic measurements were made as part of destructive test program, develop stress range versus number of cycle graph for the vessel material assuming a 2:1 reduction factor on strain range or 20:1 on mean number of cycles to failure, whichever gives the lower trend. Determine the design fatigue life.
3. Using results of proof pressure test (i.e. the percent of overpressure), a fracture mechanics analysis may be performed as an alternative to the fatigue analysis to estimate remaining cyclic life.
4. Calculate the remaining safe-life based on fatigue analysis or fracture mechanics analysis.

MAJOR OBSTACLES: If fracture mechanics approach is used, material properties.

MAJOR DECISIONS: None

INPUT: Data from destructive testing.

OUTPUT: Remaining safe-life.

RELATED ACTIVITIES: 504.

SAMPLE REFERENCES:

Manson, S.S., "Fatigue: A Complex Subject-Some Simple Approximations," Experimental Mechanics, Vol. 5, No. 7, pp. 193-226, July, 1965.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

506

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Perform Engineering Analysis to Determine Disposition

PURPOSE: To evaluate options available for vessel operation if, under current conditions, vessel exceeds design fatigue life.

DESCRIPTION: Following detailed testing and additional fatigue analysis, a vessel may continue to indicate a current cyclic life in excess of design fatigue life. Determination of operation at reduced safety factors, with operational constraints, or combinations of the two, may be appropriate. In addition, operation at lower stress levels (i.e., lower MAWP) may be applicable to extend fatigue life. All of these options should be considered and evaluated.

STEPS WITHIN THE ACTIVITY:

1. Consider alternatives to removal from service (i.e., reduction of safety factors with operational constraints, reduced MAWP, etc.)
2. Evaluate operational requirements and alternatives.
3. Based on previous steps, estimate cost of alternatives with consideration of the following:
 - a. A reduction of safety factor to 3:1 or below may require facility modification to establish safe distances between vessel and personnel or equipment, or erection of barriers based on energy release calculation assuming vessel failure.
 - b. A reduction in MAWP may not meet operational requirements for pressure or storage volume and thus require addition of capacity through procurement of stationary vessels or mobile storage vessels.
 - c. Operational constraints may unacceptably impact facility schedules or vehicle/laboratory requirements and must be addressed from cost of operational changes, schedule adjustments, or other consideration.
4. Recommendations should be established based on safety, cost, schedule and operational constraints for review by safety and management personnel.

MAJOR OBSTACLES: Reduced safety factors may not be allowed by operations or safety representatives.

MAJOR DECISIONS: Establishment of recommendations by priority for review and evaluation by management.

INPUT: Engineering analysis and testing results.

OUTPUT: Disposition options.

RELATED ACTIVITIES: 200 series, 501, 504, 505.

SAMPLE REFERENCES: Site/facility policy documents.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

507

PHASE: V, Final Evaluation and ISI Initiation.

ACTIVITY: Remove from Service and Finalize Disposition

PURPOSE: To remove unsafe vessels from service.

DESCRIPTION: It may be necessary to permanently remove a vessel from service due to unrepairable defects found during inspections/test or due to confirmation of engineering/material concerns as uncorrectable.

STEPS WITHIN THE ACTIVITY:

1. Notify safety and operational organizations of concern and indicate if imminent safety of personnel or equipment is involved.
2. Remove from service as directed and finalize disposition. Vessel should be "red tagged" as appropriate to meet site safety guidelines and disabled to prevent further unauthorized operations (e.g. drill hole in head or shell, remove key element for operation, etc.). Disposition of the vessel should include appropriate requirements or restrictions on removal such as scrapping, selling of vessel to commercial operator for low pressure service, transfer to government surplus, etc. If vessel should not be used in future service, the nameplate should be marked appropriately and the vessel should be permanently labelled to prevent future unauthorized return to service.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Replacement capacity for removed vessel will be required, this may be supplied from portable vessels, storage dewars or alternate sources.

INPUT: Findings from inspections/tests.

OUTPUT: Report on disposition.

RELATED ACTIVITIES: 405, 506.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: V, Final Evaluation and ISI Initiation

508

ACTIVITY: Derate Vessel to MOP +10% and Adjust Relief Valves.

PURPOSE: To establish a MAWP consistent with MOP requirements for the operating facility.

DESCRIPTION: If the remaining safe-life is determined to be less than required, the stress levels in the vessel may be reduced, thus reducing the maximum alternating stress (from S-N curves) and therefore providing the possibility for extended fatigue life. This is also true for safe-life as determined by other failure mechanisms including corrosion and creep. The maximum increase in life is associated with reducing MAWP to MOP plus a margin to allow for variability in relief device setting. An average value of 10% was chosen, however, the investigator may adjust this to actual available information.

STEPS WITHIN THE ACTIVITY:

1. Determine MOP.
2. Establish margin between MOP and MAWP.
3. Establish derated MAWP at MOP + margin, 10% can be used in initial calculations to determine extended life.
4. Derate vessel to new MAWP and adjust relief valves at no higher than MAWP.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Maximum Operating Pressure requirements for facility.

INPUT: MOP.

OUTPUT: MAWP.

RELATED ACTIVITIES: 506.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: V, Final Evaluation and ISI Initiation

509

ACTIVITY: Calculate Remaining Safe-Life Based
on Corrosion Rate.

PURPOSE: To establish remaining safe-life based on constant corrosion rate.

DESCRIPTION: Based on ultrasonic thickness measurements a corrosion rate may be determined. This corrosion should be evaluated and determined to be uniform prior to using this activity to determine remaining safe-life. Using the estimated corrosion rate, a remaining safe-life is calculated using the design minimum wall thickness at MAWP as the life limiting value. If other non-uniform corrosion is present, alternate approaches must be considered in life prediction.

STEPS WITHIN THE ACTIVITY:

1. Establish corrosion rate using age of vessel (years in corrosive service), original wall thickness, and current wall thickness.
2. Establish current minimum wall from ultrasonic thickness measurements.
3. Calculate the minimum number of years, remaining safe-life, required to reach design minimum wall at MAWP.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: Ultrasonic thickness mapping of vessel.

OUTPUT: Remaining safe-life (corrosion).

RELATED ACTIVITIES: 208, 301, 401.

SAMPLE REFERENCES:

National Board of Boiler and Pressure Vessel Inspectors, National Board Inspection Code.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

510

PHASE: V, Final Evaluation and ISI Initiation.

ACTIVITY: Perform Engineering Analysis to Estimate Corrosion Damage and Remaining Safe-Life.

PURPOSE: To perform engineering analysis on corrosion damage, other than uniform damage, to determine remaining safe-life.

DESCRIPTION: Corrosion damage can occur in a wide variety of forms including localized (pitting) corrosion, intergranular corrosion, crevice corrosion, stress corrosion cracking, and stress-enhanced corrosion. Each has unique characteristics and are applicable to specific types and groups of materials. In particular, historical data on a materials response to corrosion is important, as are results of NDE and other testing. This activity uses stress corrosion cracking as an illustration of the approach, however, other corrosion mechanisms may be more significant in particular environments and applications.

STEPS WITHIN THE ACTIVITY:

1. Determine corrosion mechanisms of importance to material under investigation.
2. Evaluate corrosion mechanism to determine remaining life.

MAJOR OBSTACLES: Determination of corrosion mechanisms and available data.

MAJOR DECISIONS: None.

INPUT: Historical documentation on material properties and environmental effects.

OUTPUT: Remaining safe-life (non-uniform corrosion).

RELATED ACTIVITIES: 208, 300, 400 series.

SAMPLE REFERENCES:

1. Metals Handbook, Volume 13, Corrosion, 9th edition, American Society for Metals, 1987.
2. MIL-HBK 729, Corrosion and Corrosion Prevention Metals, 1983.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: V, Final Evaluation and ISI Initiation

511

ACTIVITY: Calculate Remaining Safe-Life Based on Creep Rate

PURPOSE: To calculate remaining safe-life based on long-term, steady-state creep.

DESCRIPTION: At high temperatures and constant stress loads, a material may experience creep. This generally is not of concern under 600°F and becomes significant over a wide range of temperatures (700-900°F) for the wide variety of steels used in pressure vessel fabrication. This activity addresses only long-term, steady-state creep, assuming no significant effect of cyclic loads (startup/shutdown cycles) and thermal stresses. Allowable creep rates are included in the Boiler and Pressure Vessel Code for a wide variety of materials, however, inservice creep assessment is not specifically addressed. A Larson-Miller Parameter approach which provides a relationship between stress, temperature, and the time to rupture is recommended for creep prediction.

STEPS WITHIN THE ACTIVITY:

1. Determine pressure and temperature history for vessel (i.e. number of hours of operation at a given pressure and temperature).
2. Determine nominal stress for vessel.
3. Obtain stress-rupture data for material from ASTM standards.
4. Determine Larson-Miller Parameter (LMP).
5. Calculate creep life and remaining creep life.

MAJOR OBSTACLES: Determination of pressure/temperature/time histories.

MAJOR DECISIONS: None.

INPUT: NDE (replication) results indicating creep damage and history of high temperature service.

OUTPUT: Remaining Safe-Life (creep).

RELATED ACTIVITIES: 100, 400 series.

SAMPLE REFERENCES:

1. Larson, F.R., and J. Miller, "A Time - Temperature Relationship for Rupture and Creep Stresses", Trans. ASME, Volume 34, 1952, pp. 765-771.
2. Smith, G.V., ASTM Data Series Publications, American Society for Testing and Materials, Philadelphia, Pennsylvania.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

512

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Perform Engineering Analysis to Estimate Creep Damage and Remaining Safe-Life.

PURPOSE: To perform engineering analysis on creep damage, other than uniform damage, to determine remaining safe-life.

DESCRIPTION: Vessel steel is usually designed for service under creep conditions within limits provided by the ASME B&PV Code. For example, at temperatures in the creep range, the maximum allowable stress value for all materials shall not exceed the lowest of the following: (1) 100% of the average stress for a creep rate of 0.01%/1000 hr.; (2) 67% of the average stress for rupture at the end of 100,000 hr; or (3) 80% of the minimum stress for rupture at the end of 100,000 hr. This activity is designed to address creep damage when uniform damage cannot be assessed or when operation exceeds 100,000 hr limits provided by the Code. This activity assumes analysis is combined with in-field assessment using replication or other related assessment technique.

STEPS WITHIN THE ACTIVITY:

1. Determine pressure and temperature history.
2. Evaluate stresses.
3. Review and evaluate results of creep damage assessment.
4. Develop approach for life assessment.
5. Conduct life assessment.

MAJOR OBSTACLES: The evaluation of creep damage may require extensive field assessment, destructive examination, and analysis.

MAJOR DECISIONS: Extent of assessment based on probable life extension and cost of replacement.

INPUT: Pressure/temperature history, field assessments, destructive examinations.

OUTPUT: Remaining creep safe-life.

RELATED ACTIVITIES: 100, 400 series, 511.

SAMPLE REFERENCES: Numerous references are available, two sources of current research are:

1. Residual-Life Assessment, Nondestructive Examination, and Nuclear Heat Exchanger Materials, Proceedings of the 1985 Pressure Vessel and Piping Conference, S.J. Brown, ed., PVP - Vol. 98-1, American Society of Mechanical Engineers, 1985.
2. Design and Analysis Methods for Plant Life Assessment, T.V. Narayanan, S. Palusamy, ed., PVP - Vol. 112, American Society of Mechanical Engineers, 1986.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: V, Final Evaluation and ISI Initiation

513

ACTIVITY: Calculate Safe-Life Based on Additional Failure Mode

PURPOSE: To assess remaining safe-life if an additional unaddressed failure mode exists which may control remaining life.

DESCRIPTION: If a failure mode likely to control the remaining life was not included in the assessment of fatigue; corrosion; or creep life, then a separate assessment is necessary. This may be associated with erosion, mechanical shock, unusual loadings or configurations, or other unaddressed mechanisms. The evaluation of erosion is similar in nature to that of uniform corrosion in that detection and monitoring is associated with wall thickness measurements or internal visual examinations and prediction is associated with the estimation of past history. Other failure mechanisms such as shock or unusual or non-routine loadings are more difficult to historically evaluate or estimate future impact. This activity must be applied on a case-by-case basis and is typically used when failures have occurred in the vessel under consideration, or a similar vessel of similar material properties or configuration.

STEPS WITHIN THE ACTIVITY:

1. From previous reviews and analysis, determine whether an unaddressed failure mechanism which may control safe-life exists.
2. Assess impact on remaining safe-life.
3. Determine remaining safe-life.

MAJOR OBSTACLES: Obtaining sufficient documentation and data to perform analysis.

MAJOR DECISIONS: None.

INPUT: Concerns from previous activities.

OUTPUT: Remaining safe-life for additional failure mode.

RELATED ACTIVITIES: 100, 200, and 500 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

514

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Compare Safe-Life as Predicted by Failure Mechanisms

PURPOSE: To determine most limiting failure mode as determined by safe-life predictions.

DESCRIPTION: Remaining safe-life has been evaluated based on fatigue, corrosion, creep, and other mechanisms. The comparison of remaining life will be the basis for the prediction of subsequent recertification and inservice inspection requirements.

STEPS WITHIN THE ACTIVITY:

1. Compare safe-life predictions by evaluating assumptions made, safety-factors used, and uncertainties with predictions.
2. Summarize comparison.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: Analysis from safe-life analyses.

OUTPUT: Comparison of safe-life predictions.

RELATED ACTIVITIES: 500 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: V, Final Evaluation and ISI Initiation

515

ACTIVITY: Choose Most Limiting Safe-Life

PURPOSE: To select the most limiting remaining safe-life prediction for development of recertification and inservice inspection requirements.

DESCRIPTION: Based on the conclusions developed in the previous activity, select the most limiting remaining safe-life. The previous safe-life analyses were based on fatigue, corrosion, creep, or other failure modes, with a wide variety of assumptions, resulting in a wide variety in confidence for the safe-life prediction. The resulting number of years (or cycles) of remaining life should be evaluated by comparing failure mechanisms and the most limiting safe-life prediction taken as the safe-life for the vessel. If there is one failure mechanism which significantly dominates over the others, recommendations may be made to monitor this mechanism more closely over the first 2 to 5 years of the program to confirm assumptions. If these assumptions are found to be too conservative, follow-up adjustment in safe-life prediction may be warranted.

STEPS WITHIN THE ACTIVITY:

1. Evaluate level of confidence in remaining safe-life predictions.
2. Select most limiting safe-life prediction.
3. Adjust inservice inspection recommendations to re-evaluate safe-life during early years of ISI program.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Level of confidence in safe-life predictions.

INPUT: Safe-life predictions.

OUTPUT: Most limiting remaining safe-life.

RELATED ACTIVITIES: 500 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

516

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Define Recertification Period Equal to 20 Years

PURPOSE: To establish a maximum recertification period.

DESCRIPTION: The remaining safe-life calculated by this program may well exceed 20 years, including applied safety factors. The 20 year maximum recertification program is included to allow for a periodic review based on advances in knowledge of design, fabrication, material, and inspection and test techniques. Since the 20 year recertification period is a maximum value established for this program, the recertification manager may shorten this period based on concerns with operating conditions such as environment, service commodities, or proximity to personnel or critical equipment.

STEPS WITHIN THE ACTIVITY:

1. Determine most limiting remaining safe-life prediction, including safety factors, and additional circumstances which may affect selection of recertification period.
2. Select recertification period with maximum value of 20 years.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Evaluation of additional circumstances which may require additional safety factors.

INPUT: Most limiting remaining safe-life.

OUTPUT: Recertification period.

RELATED ACTIVITIES: 500 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

517

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Define Recertification Period Equal to Remaining Safe-Life

PURPOSE: To establish the recertification period when the remaining safe-life is determined to be less than 20 years.

DESCRIPTION: The maximum recertification period may be set at the remaining safe-life assuming that the remaining safe-life calculations have an adequate level of conservatism, i.e. includes safety-factors to adjust for level of uncertainty in available data. The recertification manager may reduce the recertification period by additional safety-factors based on conditions such as environment, service commodity, or proximity to personnel or critical equipment. Typical recertification periods can be expected to range from 10 to 20 years in the early years of a vessel's lifetime. As the vessel ages, the recertification period may be adjusted to shorter intervals to provide the appropriate level of conservatism when operating near a vessel's design lifetime. Lifetimes of 50 or more years are expected for most ASME Code stamped vessels, and with appropriate ISI and repair programs, the lifetimes may significantly exceed this value. The key in setting a recertification period is its dynamic nature, that is, the cognizant engineer may adjust recertification intervals as level of confidence changes.

STEPS WITHIN THE ACTIVITY:

1. Determine remaining safe-life, documented safety-factors, and additional requirements.
2. Establish recertification period.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Need to include additional safety-factors.

INPUT: Remaining safe-life.

OUTPUT: Recertification period.

RELATED ACTIVITIES: 500 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

518

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Develop Inservice Inspection Plan
Based on Recertification Period

PURPOSE: To establish routine and major inservice inspection and test requirements.

DESCRIPTION: Major and routine inservice inspections and tests are prescribed throughout the recertification period to provide assurance that concerns developed during prior recertification periods are monitored and re-evaluated as necessary. A major inspection includes nondestructive examination which assess the volumetric integrity of the vessel. This may include radiography, ultrasonic, or acoustic emissions examination (proof testing may be used as an alternative). Routine inspections include visual and nondestructive examinations which assess the overall condition of the vessel. This may include visual and ultrasonic wall thickness measurements, and may require follow-up inspections. Other inspection techniques, such as replication, may be included on a case-by-case basis as needed to address a specific failure mechanism.

STEPS WITHIN THE ACTIVITY:

1. Review list of concerns and applicable failure mechanisms.
2. Establish major inspection interval at 1/4 to 1/2 of the recertification period. Designate NDE technique and acceptance criteria, as applicable.
3. Establish routine inspection interval at 1/10 to 1/2 of the major inspection interval. Designate NDE technique and acceptance criteria, as applicable.
4. Establish personnel qualifications for performance of ISI program.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Selection of number of major and routine exams performed during recertification period.

INPUT: Results of all activities.

OUTPUT: Inservice Inspection and Test (ISIT) plan.

RELATED ACTIVITIES: All activities.

SAMPLE REFERENCES:

Nondestructive Inspection and Quality Control, Metals Handbook, Volume 11, American Society for Metals, current edition.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

PHASE: V, Final Evaluation and ISI Initiation

519

ACTIVITY: Resolve All Outstanding Concerns and Establish MAWP and Service Restrictions

PURPOSE: To finalize program concerns, establish long-range plans, MAWP and service restrictions.

DESCRIPTION: All outstanding concerns should be addressed with long-range plans and established review dates for resolution. The MAWP and service restrictions are also documented. The long range plans may be allowed under a waiver for operation, as would MAWP or service restrictions. The key in this activity is to establish milestones and commitment dates for resolution of all outstanding concerns.

STEPS WITHIN THE ACTIVITY:

1. Establish plan for resolution of all long-term concerns, including target date for resolution.
2. Document MAWP and service restrictions.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: Target date for resolution of long-term concerns.

INPUT: List of outstanding long-term concerns.

OUTPUT: Plan for long-term concerns, MAWP, service restrictions.

RELATED ACTIVITIES: 200, 400, and 500 series.

SAMPLE REFERENCES: None.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

520

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Establish Overpressurization Protection Requirements

PURPOSE: To document overpressurization protection following final establishment of MAWP.

DESCRIPTION: The program involves numerous opportunities to adjust the MAWP of the pressure vessel, based on analysis, inspection, or testing results. This activity establishes and documents that the pressure vessel, with final MAWP, has appropriate relief protection.

STEPS WITHIN THE ACTIVITY:

1. Determine MAWP.
2. Determine margin below MAWP to be used to establish relief device setting.
3. Set and certify overpressurization protection.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: MAWP.

OUTPUT: Relief device settings.

RELATED ACTIVITIES: 519.

SAMPLE REFERENCES: ASME Boiler and Pressure Vessel Code, Section VIII, Divisions 1 and 2.

RECERTIFICATION GUIDE

ACTIVITY
NUMBER

521

PHASE: V, Final Evaluation and ISI Initiation

ACTIVITY: Establish Date for Next Recertification
and Initiate ISI

PURPOSE: To schedule next recertification and initiate ISI program.

DESCRIPTION: An important part of the program is the establishment of a schedule for recertification and routine and major inspections. See Figure 3 of Section 1 of this report for guidance on establishment of inspection intervals.

STEPS WITHIN THE ACTIVITY:

1. Establish tracking system for routine and major inspections and recertification, along with formal schedule.
2. Assign ISI program management and initiate ISI program.

MAJOR OBSTACLES: None.

MAJOR DECISIONS: None.

INPUT: Recertification and ISI requirements.

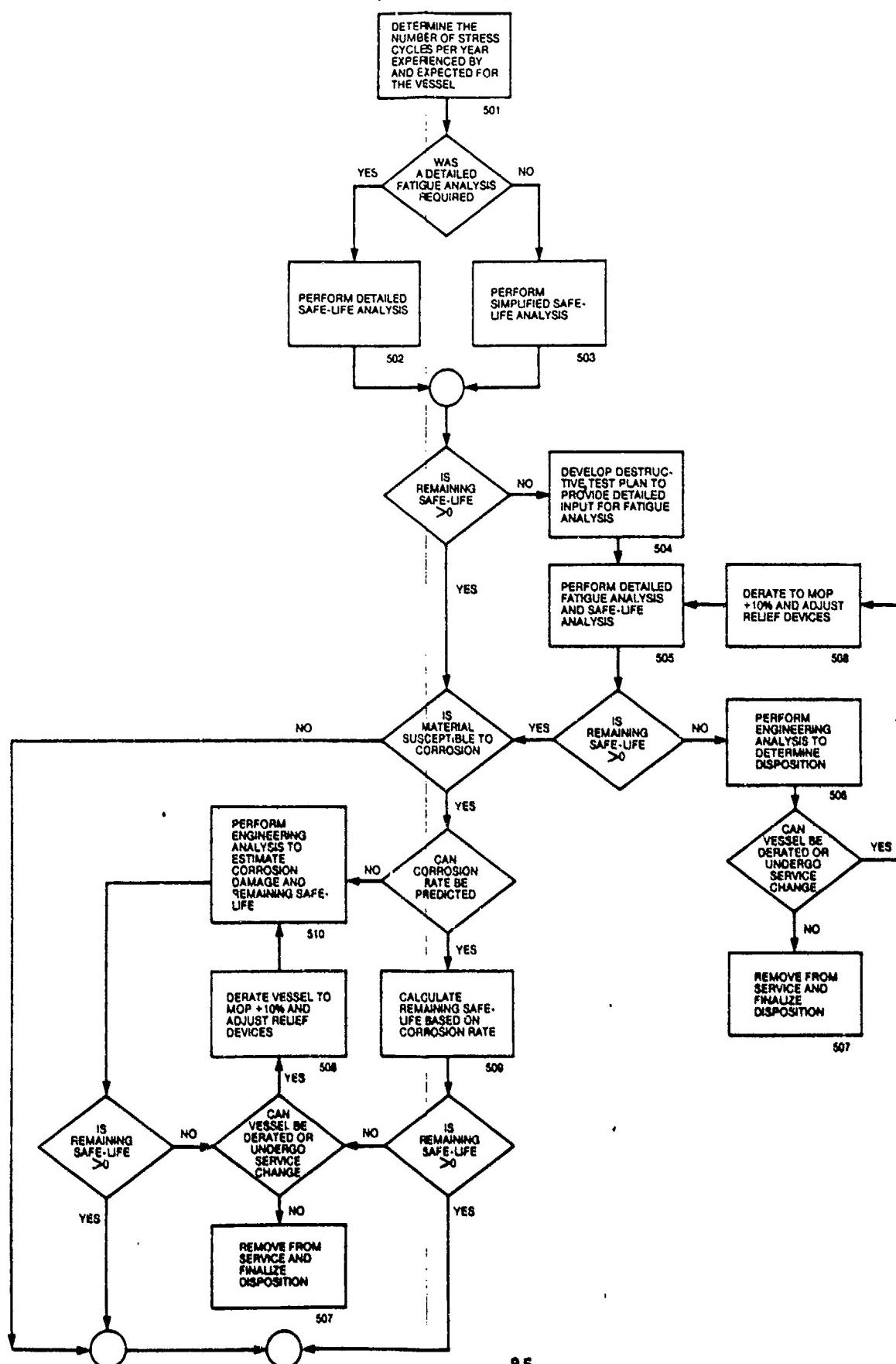
OUTPUT: Recertification date and next routine and major inspection.

RELATED ACTIVITIES: 517, 518.

SAMPLE REFERENCES: None.

PHASE V: FINAL EVALUATION AND ISI INITIATION

(Sheet 1 of 2)



**PHASE V: FINAL EVALUATION AND
ISI INITIATION**

(Sheet 2 of 2)

